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THE EARTH
IN RELATION TO
THE PRESERVATION AND DESTRUCTION OF
CONTAGIA
BRING THE MILROY LECTURES DELIVERED AT THE
ROYAL COLLEGE OF PHYSICIANS IN 1899
TOGETHER WITH
OTHER PAPERS ON SANITATION

BY
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PREFACE

THE Author feels that no excuse is needed for the republication of the lectures and papers included in this volume, which deal with subjects of national importance.

To Mr. GEORGE PERNET, M.R.C.S., &c., his warmest thanks are due for much invaluable help in passing the volume through the press.

May 1902.



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THE EARTH

IN

RELATION TO THE PRESERVATION AND DESTRUCTION OF CONTAGIA*

CHAPTER I

EARTH—PATHOGENIC SAPROPHYTES—TETANUS

THAT which we commonly speak of as earth, soil, or humus, is largely composed of excreta and the dead remains of animals and vegetables, which, as the result of fresh biological processes, are either returned to the bodies of living vegetable organisms, or, after becoming mineralised and soluble, are washed downwards by the rain and ultimately find an exit in the sea. It is obvious that not only does 'earth' vary in composition with the varying conditions of subsoil, climate, flora and fauna, but that 'earth' must undergo seasonal variations necessitated by the vigorous upgrowth in the spring or the decay of the fall—the heat and drought of summer or the flood and frost of winter. The interstices between the particles of

* Being the Milroy Lectures delivered before the Royal College of Physicians, London, in 1899 (Chapters I. to XIV. inclusive).

'earth' are filled at one time with air, at another time with water, and the line of demarcation between earth and air on the one hand and earth and water on the other is often not very definite. Again, the dust which is suspended in the air and which settles on everything is liable to contain infective particles, harmless to breathe but dangerous if they fall upon a wound. It is obvious that such particles may be regarded as belonging to the earth or the air. Some of them doubtless emanate from the earth, having been raised as dust; but we must admit that there may be organisms which grow in the air, live in the air, and die in the air without ever touching earth or water and which elude all attempts at identification or artificial cultivation. While there are organisms which may live indifferently in air or water, others are probably more exclusive in their obligatory conditions. The mutual interaction of earth, air, and water must never be lost sight of. It is the life in the earth, both vegetable and animal, which helps by its influence on vegetation to maintain the quality of the atmosphere. Again, it is the earth which gives the quality to spring and river water. Pure water is a body of definite chemical composition, and pure air is a tolerably definite mixture of gases, and it is not difficult approximately to measure the degree of pollution of either. The chemical composition of earth, on the other hand, is complex and constantly changing, and it is not possible for the chemist to fix any standard of quality. The practical agriculturist by the aid of touch, smell, and vision will say at once whether any given sample of earth is fair or pure, sour or sweet, rich or poor, fertile or sterile and we must perfume content ourselves with the terms used by the practical man. The word 'earth' is

PATHOGENIC ORGANISMS

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ensuing lectures will usually be regarded as meaning humus in a healthy condition.

There are certain pathogenic organisms which are constantly found in the earth and which appear to be ubiquitous. They adhere to our skin and clothing, get under the nails, and lodge in the hair. They produce various diseases of wounds and wounded persons, and we now recognise that in the absence of those precautions which we call 'antiseptic' it is never safe to inflict even the smallest wound. The modern surgeon not only renders his hands and instruments aseptic, but he operates in spotless garments and endeavours to have an operating-room as clean and free from dust as possible. The organisms which produce the various wound infections are saprophytes which flourish externally to the body. They are ubiquitous and (probably) necessary, and so long as we have a whole skin and uninjured mucous membrane they do us no harm.¹ As all organic matter is constantly circulating, passing through death to other forms of life and necessarily undergoing humification as it does so, it follows that the agents of these changes, the microbes, which are to this end propagated in the soil, vary with the circumstances. Houston¹ gives the estimated number of microbes per gramme found in twenty-one samples of soil. These vary from 8,326 in a virgin sand and 475,282 in a virgin peat to 115,014,492 in the soil from the trench of a sewage farm. Broadly speaking, the microbes bear a proportion to the amount of dung. Warington estimated that a gramme of dung from a cow fed on hay contained 165,000,000. They all, presumably, have their optimum conditions—chemical and physical qualities of the nutritive medium, access of air or other gases,

¹ Local Government Board Report, 1897-98.

lightness or darkness and temperature—and when the optimum conditions concur, growth and multiplication go forward at a pace which we can hardly appreciate.) The fact that for the growth of some the access of air is necessary, while others obtain their oxygen from the (medium in which they grow, and others, again, are able to take in oxygen from either source, has formed the basis of a classification which has assisted our understanding. (Saprophytes, including those which produce wound infection, are presumably of service in bringing about the decomposition of complex organic bodies.) Whether we are able to check the growth and multiplication of these facultative parasites outside the body is doubtful, and whether or no we should be gainers or losers by so doing is still more doubtful. Bacteriologists have experienced no little difficulty in discovering the exact conditions which are necessary for the growth and development of many of the micro-organisms which have been studied. Some are more exacting than others, and those which are best able to accommodate themselves to varying circumstances naturally obtain the mastery when several are attempting to grow simultaneously in the same medium. (Some of the larger saprophytes, such, for instance, as the common mushroom, require no little skill for their artificial production.) Their cultivation requires far more attention to exact details than is necessary with ordinary green-leaved garden plants. We know that for a few weeks in the autumn they may appear in great numbers in dry pastures where horses have been fed, provided the conditions of the air as to temperature, light, and moisture be favourable, and we also know that directly the necessary conditions fail the mushroom harvest is at an end. We also know how strange is the predilection of certain

fungi for the dung of particular animals, and I would allude to a list furnished to me by Mr. George Murray, F.R.S., which shows that the optimum conditions for the growth and development of these short-lived and delicate organisms must be marvellously subtle and probably quite beyond the ken of the chemist.

(TETANUS)

I will now proceed to deal seriatim with some of the contagia which are best understood, and will begin with tetanus. Among the ubiquitous organisms which are habitually found in earth is the bacillus of tetanus. It is said to be present in almost all rich garden soils and that the presence of horse-dung favours its occurrence. It is strictly anaerobic and has been artificially cultivated by Kitasato in an atmosphere of hydrogen. It forms spores and grows best at a blood heat. Marchesi has found it at a depth of two metres but no lower. The pure cultivation of the bacillus, which has a disagreeable aromatic odour, is often not very virulent. It is fatal to animals as well as man, and among animals the horse appears to be most liable to be attacked. Infection always takes place by inoculation through the wounded skin or mucous membrane—never, it is believed, through the healthy alimentary or respiratory tracts. Cases of 'idiopathic' tetanus are reported, but it has fallen to the lot of few of us to see a case, and professional opinion seems to lean to the idea that in such cases the inoculating wound has been overlooked. The toxin which the bacillus brews locally in the wound is toxic to the central nervous system, and the antitoxin to be effectual must, it is said, be injected subdurally into the central nervous system. The exhaustion of the nervous system seems to increase its vulnerability, which is, perhaps, the reason

why tetanus has been relatively common in the domain of military surgery. There seems to be no doubt as to the ubiquity of the tetanus germ. Every child who falls on the ground and gets an abrasion of the skin, all tillers of the soil who get accidental wounds in the course of duty, and every horse which 'breaks its knees' by falling in the London streets, runs, potentially, a risk of inoculation with tetanus. In the face of the ubiquity of the cause the rarity of the disease is remarkable. I have made inquiry of many practitioners in the Thames valley, where market gardening is the chief industry and where countless tons of London horse-dung are spread upon the land, and learn from them that tetanus is in their experience the rarest of diseases. Seeing that the bacillus is so strictly anaerobic one is justified in supposing that the tillage of the soil, which brings it in contact with air and sunshine, must be unfavourable for its growth and virulence. The bacilli must die out under such conditions and the inoculation of the spores alone is said by Vaillard, Rouget and Vincent to be incapable of setting up tetanus. If the bacillus or the spore be carried in dust, or if they be washed into the water and drunk, we have no evidence that any harm results therefrom. In common with some other microbial diseases tetanus is more virulent in the tropics than in temperate climates. Friedberger and Fröhner state that it is so common among horses in St. Domingo, especially after the operation of castration, that geldings are worth twice as much as stallions.

The statement made by Le Dantec and H. M. Stanley that the natives of the New Hebrides and Central Africa are in the habit of poisoning their arrows by smearing them with mud (obtained in the New Hebrides from a mangrove swamp) gives emphasis to the importance of

TETANUS

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a tropical temperature and the absence of tillage as factors which make for increase of virulence of the tetanus bacillus and other organisms found in earth. Pus from the wound of an animal suffering from tetanus is capable of conveying the disease, and perhaps it is due to this fact that certain stables and pastures have at times acquired an evil reputation in respect of tetanus. Captain Hayes, F.R.C.V.S., is of opinion that wounds in the hoof as the result of careless shoeing are a great cause of what may look like idiopathic tetanus in horses. In an article by Mr. Sidney Villar in the 'Journal of Comparative Pathology and Therapeutics' for December, 1897, an observation by Mr. Joseph Woodger is quoted to the effect that tetanus is particularly common among horses used in dust-carts, and Mr. Villar continues : "In my own practice in Middlesex there are two farms where the disease is specially prevalent. One of these, at Alfreton, is occupied by a farmer who habitually spreads on his fields large quantities of London refuse ; at the second farm, five miles away, the bailiff brought two large loads of the sweepings of London roads in 1893 and dressed his home meadows with it. On these meadows his colts and young stock were pastured and for two and a half years tetanus was endemic on his farm ; during this period six colts became affected and I believe only one entirely escaped the disease."

This experience of Mr. Villar seems to point to the danger of placing upon grazing land material which is probably mixed with broken glass or crockery. On clay lands, such as are common in the north of London, manurial matters placed on a pasture would be long in getting incorporated with the soil, and to allow horses to browse amongst the crude impurities of a great city cannot be without danger to the horses. Municipal

authorities who wish to find a ready market for street refuse must clearly take care that it is not mixed with dangerous materials of no manurial value likely to wound the feet of animals. Inorganic refuse, such as old metal, crockery and glass, should be placed two feet beneath the surface, while organic matter should be kept near the surface where it is accessible to tillage. In connection with Marchesi's observation that the tetanus organism has not been found at a greater depth than two metres, I would allude to a fact to which I shall return later, that this approaches the maximum depth to which the earthworm burrows. It is obvious that if a spore were carried downwards by a worm, it would there meet with anaerobic conditions favourable for its preservation. A review of the main facts connected with tetanus cannot but rouse in us some surprise that in the face of the ubiquity of the cause the disease in man should be so rare. This is probably in part due to the fact that we wear boots.

CHAPTER II***ANTHRAX***

ANTHRAX is a disease which undoubtedly is connected with the soil. The bacillus was discovered by Pollender in 1849, a discovery which is just fifty years old and which marks the dawn of pathological bacteriology. The identification of the bacillus in the laboratory, and the diagnosis of the disease in animals from quarter-evil and septicæmia, is not without difficulty. These difficulties are now understood, but they are sufficient to throw a shade of doubt over some of the earlier observations. It may be well in the first place to give some of the facts collected by Pasteur without comment.

M. Chamberland, the able assistant of M. Pasteur, in his work¹ gives a *résumé* of what one may call the modern history of charbon. In 1842 a Government report showed that in France the disease raged among the flocks of half-bred merino sheep belonging to farmers in la Beauce. It especially attacked lambs, and the losses in this district of la Beauce amounted to as much as 20 per cent. (out of a total of some 1,800,000 sheep) "et souvent dans les localités dont le sol est sec et calcaire la mortalité va jusqu'au quart, au tiers et dépasse parfois la moitié du troupeau." In the department of Seine-et-Marne and in the districts of Provins,

¹ *Le Charbon*, Paris, 1888.

Fontainebleau, and Meaux are certain farms known as *fermes à charbon*—"les meilleurs cultivateurs ne les louent qu'en tremblant." Also in le Cantal charbon is known as 'mal de montagnes' and certain hills are known as 'montagnes maudites' because of their evil reputation in relation to charbon. The animals stricken with charbon show for a few days some excitability and passing dyspncea, and they become distended after feeding. Next the urine becomes bloody, and it is a sign of bad omen to see fleeces spotted with blood. The dung also is noticed to be soft and slimy, of a whitish colour stained with blood. They die at last somewhat suddenly, and in doing so usually void some blood-stained dung and urine, and expel bloody froth from the nostrils. Post-mortem decomposition is rapid, and the animal swells up and blood is expelled from the nostrils. Hæmorrhages are found in the skin and cellular tissue, as also in the viscera, which are engorged with blood.

The discovery of Bacilli anthracis in the blood clinches the diagnosis. It was in 1850 that Rayer and Davaine described the bacilli, and in 1877 Pasteur communicated to the Academy of Sciences the important fact of sporulation observed in these bacilli by Koch and himself, and further pointed out that the *Bacillus anthracis* was essentially aerobic and was quickly destroyed in the blood of the dead animal after the onset of putrefaction. It is important to take notice of the extent to which the ground is soiled by the dung, discharges, urine, and bloody wool of an animal ill with anthrax.

In August 1878, M. Pasteur fed sheep on lucerne previously watered with a pure cultivation of *Bacillus anthracis*. He says that "in spite of the immense number of spores taken in with the food many of the

sheep escaped death. . . . The communication of the disease in this way is still more difficult in the case of guinea-pigs." "Nous n'en avons pas obtenu d'exemple dans d'assez nombreuses expériences. Les spores, dans ce cas, se retrouvent dans les excréments. On les retrouve également intactes dans les excréments des moutons." [The mortality is much increased when the infected food is mixed with prickly material such as the leaves of thistles and the chopped beards or husks of barley, and the post-mortem examination of sheep rendered 'charbonneux' by fodder of this kind gave reason to suspect that they were in fact really 'inoculated' by definite injury by the prickly food to the back of the throat. Of nineteen sheep fed on lucerne polluted with spores, three died after four, seven, and nine days; of eleven sheep, fed on polluted lucerne and thistles, three died after three, four, and six days.]

It is recognised by professional 'knackers' that they run little risk of contracting 'charbon' by manipulating dead animals far advanced in putrefaction, and both Pasteur and Koch have shown that putrefaction soon destroys the bacilli in the blood and tissues of an animal, and that the *Bacillus anthracis* being aerobic, sporulation does not take place inside the putrefying body, but is very liable to occur in the blood which escapes from it, whether the blood flow upon the earth or upon a dung-heap.

In August 1878, Pasteur made a necropsy on the body of a sheep, and then buried the carcass in M. Maunoury's garden. Ten months afterwards Pasteur found spores of anthrax in the earth of this animal's grave, and established the fact by the inoculation of guinea-pigs. The spores were found in the surface soil

over the grave, although since the burial the ground had not been moved. Similarly spores were found in the soil over the grave of a cow buried two years previously, and at a depth of two metres. These spores were found over the graves of dead animals after all the operations of cultivation and harvest. Earth taken at a distance from these graves did not give charbon.

In announcing these facts to the Academy of Sciences in July 1880, Pasteur says: "I shall not be surprised if doubts arise in the minds of the Academy as to the correctness of these facts. It will be asked, 'Does the earth, which is so potent as a filter, allow these microscopic spores to rise to the surface?' These doubts seem to be supported by facts already published by M. Joubert and myself. We have announced that water from even superficial springs is sterile. . . . These, in spite of conditions above which make for pollution, keep perfectly pure, which shows that a certain thickness of earth arrests all solid particles." Pasteur attributes the uprising of spores to the action of earthworms, and he claims to have actually recovered spores from the bodies of earthworms living in soil polluted with anthrax.

"May not 'earthworms,'" asks Pasteur, "bring other noxious germs to the surface? They are always filled with a mixture, and the spores of charbon are in them mingled with germs of putrefaction and septicæmia." Pasteur at this time regarded the earthworm as the great cause of the dissemination of anthrax. In a footnote Pasteur calls attention to the fact that in le Cantal there are pastures which from time immemorial have escaped (*sont épargnées*), and others in which from time to time the cattle were decimated and

EXPERIMENTAL

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which are known as '*montagnes dangereuses*,' which are abandoned without deriving the least profit from them, "at least during several years," says M. Baillet.¹ "This last circumstance deserves great attention. It proves that the cause, whatever it may be, which produces charbon in a locality disappears with time." In la Beauce, Pasteur saw certain fields in which the folding of sheep had been interdicted for several years—i.e., since the last death thereupon from charbon. "Now we placed flocks of sheep on five of these fields, and the mortality was *nil* except in one flock where it amounted to 1 per cent."

M. Colin, of Alfort, a professor at the Veterinary School, not being satisfied with some of Pasteur's experiments, a further report was made on May 17, 1881, by a commission composed of M. Bouley, M. Davaine, M. Alphonse Guérin, and M. Villemin. Earth from a twelve-year grave, a three-year grave, and from virgin soil was kept at a temperature of 90° C. for fifteen minutes, and the fine sediment was injected into guinea-pigs. Of five guinea-pigs inoculated with twelve-year earth on March 19, four died on March 21 and 22 from septicæmia, and one died on March 23 from charbon. Of five guinea-pigs inoculated with three-year earth on March 19, four died from March 21 to 23 from septicæmia, and one died on March 23 from charbon. Of five guinea-pigs inoculated with virgin soil on March 19 none died. One had a small abscess at the seat of puncture. Of six guinea-pigs inoculated with twelve-year and three-year earth on March 30, five died from septicæmia on April 3, and one died from charbon (twelve-year earth) on April 3. Of three guinea-pigs inoculated with excreta taken from the bodies of living

¹ *Mémoires du Ministère de l'Agriculture*, 1870.

earthworms, two died from septicæmia and one from charbon on March 30. Of the nineteen animals killed by the above experiments, fifteen died from septicæmia and four from charbon.

Since 1879 M. Pasteur had asserted that most soils when inoculated were capable of causing death from septicæmia quite apart from any contamination by the death of anthrax animals. Of three guinea-pigs inoculated on March 28 with worm castings taken from above the graves of some of the victims of the Commune situated on waste land, one died from septicæmia on April 1, and two were unharmed.

Pasteur had clearly demonstrated that the anthrax bacillus is essentially aerobic, that it is soon destroyed by putrefaction, and that for sporulation free exposure to air and a temperature above 15° C. and under 45° C. are necessary. These facts seem out of harmony with the view that earthworms bring spores from a deeply buried carcass to the surface.

The following case is quoted by Pasteur.¹ On August 21, 1796, a mare fell dead from anthrax on a causeway (*digue*) at Houë (Eure-et-Loire). The animal was skinned, and the carcass was dragged by two horses all along this causeway (along which farm animals passed to and fro), with the result that the ground was soiled by the blood and other débris of the dead animal. A large number of the sheep and cows which used this soiled path died. These animals were skinned and buried, with the result that the foci of contamination spread, and ultimately 500 or 600 sheep succumbed to anthrax. The skinning and transportation of an animal dead from anthrax must necessarily be a most dangerous process.

¹ *Annales de l'Agriculture*, 1ère Série, tome xxx. p. 382.

All are agreed that anthrax is a disease liable to haunt localities. Thus, in the report of the Board of Agriculture for 1895, I find the following:

An undoubted fact in connection with anthrax is its tendency to recur on certain farms. An examination of the agricultural returns received shows that during 1895 the disease reappeared on twenty-three farms or other premises in England and six in Scotland where it had been reported in the previous year. From this cause farms come to be regarded as dangerous, and their value is very greatly depreciated. In a report issued by the German Government,¹ allusion is made to the farm of Parkisch, where anthrax was rife. "Numerous outbreaks of the disease were especially remarked when certain portions of the farm were used as pasture, and when fodder from these portions was used in the stalls. The former tenant of the farm is said to have buried on different parts of the farm carcasses of animals which had died of anthrax, and also to have put the carcasses into the dung-heap to use them as manure."

Again, "Dlouie is a large estate in Kroloen, district Posen, and is known as a hot-bed of anthrax. . . . It is stated that carcasses of animals which have died from anthrax have been buried with great carelessness on different parts of the fields, especially behind the sheep sheds and in a small wood situated some hundred paces from the farm, which also serves for pasturage, and even in the dung-heaps which together with the straw from under the diseased animals were used for manure."

It is alleged by Friedberger and Fröhner that the spores may vegetate in the soil and surface water quite independently of the animal body. The disease is said

¹ *Report of the British Board of Agriculture, 1894.*

to occur among horses, cattle, and buffaloes in Eastern Bengal, Manipur, and Burma without the agency of infection and to be in that part of the world a so-called 'miasmatic' disease. As spore formation requires something like a blood heat, it is only what might be expected to find the disease becoming endemic among cattle and horses in tropical countries. Where infected animals drop dung and other discharges on the soil it becomes impossible to say whether the infective spore originates in the soil or in the animal. The distinction which separates soil from dung is somewhat subtle. These authors assert that "there exists a well-marked connection between the disease and the amount of moisture in the soil. It appears most frequently in lowlands and plains exposed to inundations and great heat." Copeman also asserts that the disease is prevalent on damp soils containing much humus, as, for instance, upon peat bogs and near the borders of lakes and rivers which have overflowed. On the other hand, we have Pasteur speaking of *montagnes maudites* in connection with anthrax and asserting that the mortality is great in soils which are *secs et calcaires*.

Many of the outbreaks of anthrax in this country have been in the neighbourhood of Bradford and have been traced to the use of infected wool-refuse as manure. A map published by the Board of Agriculture shows that the outbreaks of anthrax are most frequent in those counties of Great Britain where dry foreign wools, hairs, hides, and skins are manufactured into goods. In 1892 there were forty-two outbreaks of anthrax in the West Riding of Yorkshire, as against two in the North Riding and one in the East Riding. Wool when used as a manure must take a long time in becoming disintegrated and humified. In this respect it is very different from

dung, and if wool be infected with anthrax spores it must be a very dangerous manure for a pasture. The chief sources of danger are said by Dr. Bell, of Bradford, to be the dry wools of goats, alpacas, and llamas which are imported very dry from hot countries. It is the anthrax spore which is the danger, and if, as is the case, a high temperature and free admission of air be necessary for sporulations an excess of water would be unfavourable for that process. There seems a concurrence of opinion that the *Bacillus anthracis* is killed by putrefaction and soon disappears in the unopened and unskinned body. Schmidt-Mühlheim inoculated guinea-pigs with anthrax and as soon as they were dead he skinned them and placed the limbs in an incubator at 39° C. The surface of the flesh was soon covered with a whitish film which was found to consist exclusively of anthrax bacilli, in many of which commencing spore formation was apparent. There can be little doubt that the soil becomes infected by the discharges from the living animal and the skinning and other manipulations of the dead one. The advice which is usually given in this country to bury anthrax carcasses deeply and unopened and unskinned is doubtless sound, although it is open to question if the depth of the grave adds materially to the anaerobism of the surroundings. It is very doubtful if in an unopened body spore formation be possible after a short period of burial. It is clear that the animal should be buried at the spot where it dies and that the spot should be enclosed and planted with a few saplings of some indigenous tree. The value of 'quicklime' is doubtful. Whether it be advisable to delay burial until quicklime can be obtained is still more doubtful.

All Pasteur's experiments in relation to graves appear to me to be vitiated by the fact that they took

place in an anthrax district, and it is very difficult to say whether the spores were derived from the buried animal, or from the dung of infected ones which had been used as manure, or from the blood-stained wool which, we are told, is of 'bad omen' in a flock. It is a noteworthy fact that of the nineteen guinea-pigs inoculated by the Alfort Commission four only died from anthrax and fifteen from septicæmia, and that the earth from the three-year-old grave and from the twelve-year-old grave conveyed anthrax in the same proportion—*i.e.* one in four inoculations. There seems no doubt that spores may be found in earthworms or their castings, and there is equally no doubt that if the worms have brought the spores from the depths of the earth such spores must have originally been formed on the surface. It is, of course, quite impossible to say whether a worm swallowed the spore on the surface or below it. It is certain that recently-dead bodies have no attractions for worms. Such carrion usually forms the food of maggots hatched from the eggs of diptera deposited before burial, and of beetles which live in the earth, and are soon attracted to it.

There are some discrepancies amongst observers as to the infectivity of food grown on anthrax ground. On the one hand, Pasteur was unable to do much harm to sheep fed on lucerne sprinkled with spores, and on the other hand, we have a story quoted by Pasteur of an old woman whose goat and cow died from anthrax when fed with clover stolen from over a grave two years after the burial of an anthrax animal. It is, of course, impossible to get away from the *post hoc* fallacy in these cases, especially in a country where animal hygiene was utterly neglected, and where anthrax was, or diseases resembling it were, rife. In this country we have had

no outbreaks of anthrax at all comparable to those which have proved such a scourge in France and other parts of the Continent. The loss of sheep from anthrax in England is very slight, and the explanation is probably to be found in the relative vulnerability and immunity¹ of the flocks. Sheep in England are rarely housed, but are allowed to breathe at all times the freshest of fresh air. Their pastures are changed before the ground gets foul, and when food is short they are either killed at once or fed upon imported food. Such a condition of things would be likely to breed immunity to disease of all kinds; and it is noteworthy that tubercle is much less common among sheep than amongst animals which are housed. When flocks are kept partly for dairy purposes, and when sheep are housed and breathe a foul air, and lie upon filth mixed with earth, it is no wonder that disease, especially such a disease as anthrax, is liable to be rife and to be difficult to eradicate.

Anthrax in the human subject is a rare disease. Man is never infected through the alimentary tract as appears to be the rule among animals. Dr. Bell, of Bradford, says that "no such case has been recorded in this country." Cutaneous anthrax (malignant pustule) is caused by direct inoculation. It occurs (1) in those who come into contact with infected animals alive or dead; (2) in those who handle offal, skins, hoofs, horns, hairs, wools or other derivatives from such diseased animals; and (3) in countries where the disease is

¹ Algerian sheep are immune to anthrax. *Ses Chauveau*, 'Nature de l'Immunité des Moutons Algériens contre le Sang de Rate. Est-ce une aptitude de race?' (*C. R. Acad. Sc.* xcl. 1880) cited by A. Billet in 'Contribution à l'Etude de la Morphologie et du Développement des Bactériacées,' Paris, 1890 (with other references).

common among animals, women and children who do not come into direct connection with infective material are not infrequently attacked with the disease through the medium of persons, animals, or insects.

Pulmonary anthrax or wool-sorter's disease was first noticed in the Bradford worsted district after the introduction of alpaca and mohair as textile materials in 1837. "This form of anthrax may attack any person exposed to the inhalation of anthrax spores in *dust* arising from the products of diseased animals." The fact appears to be undoubted that anthrax may be a dust disease and that the spores when perfectly dry may be inhaled into the lungs. And yet I have hitherto found no records of pulmonary anthrax from the inhalation of dust from highly manured ground which must, one would suppose, especially in the West Riding of Yorkshire, often contain anthrax spores. The lungs of the agricultural labourer and the market gardener appear to be immune to the infectivity of anthrax spores. It seems to be of very great importance to bear in mind : (1) that anthrax spores persist even in the finely pulverised soil of worm castings, which must be very easily dried and converted into dust ; (2) that anthrax may undoubtedly infect man by the inhalation of dust ; and (3) that pulmonary anthrax among agriculturists has not been recorded. In India it is believed by some that dust is a common cause of enteric fever among Europeans, a statement which is insusceptible of proof or of disproof. Does pulmonary anthrax occur among the rural population of the tropical countries where the disease is endemic amongst cattle ? In this connection we must bear in mind that anthrax bacilli may change their virulence without undergoing any morphological changes, and in this form when inoculated may confer

immunity on susceptible animals without apparently producing other effects. The virulence is diminished by cultivation at high (from 108° to 120° F.) or low (from 66° to 75°) temperatures, by cultivation under pressure of three or four atmospheres, by exposure to sunlight, or by admixture with other bacteria.¹) The modified organisms thus produced are not pathogenetic but confer immunity on susceptible animals for nine or twelve months. Morphologically they are indistinguishable from the most active and virulent forms of the organism, and they will generally regain their virulence when favourable conditions are restored, although the degree of virulence varies in different species of animals. The persistence of the anthrax spore in the earth does not admit of a doubt, but there is no evidence that man is ever infected directly from the earth. How far anthrax in animals is due to inoculation rather than to feeding requires further and very careful investigation.¹

¹ Pictet and Yung by a special process have subjected bacteria to a temperature as low as -180° Centigrade, without killing some of them, for instance anthrax spores. (G. von Bunge, *Physiologie des Menschen*, vol. i. 1901, p. 283.)

CHAPTER III**DIARRHŒA—DYSENTERY—CHOLERA**

DIARRHŒA is a disease which in its epidemic form has been supposed to be engendered in the earth.

The third quarter of the year 1898¹ was characterised by a very large infantile mortality, mainly attributable to diarrhoea. The rainfall for the quarter was unprecedentedly small, the temperature was above the average, and the harvest was one of the best on record.

Of the 141,540 deaths registered, 52,887 were those of infants under one year of age. The mortality of infants, measured by the proportion of deaths under one year of age to registered births, was 225 per 1,000, which is the highest proportion in any quarter for which the figures are available, and is 55 per 1,000 above the average in the ten preceding third quarters. In the thirty-three great towns as a whole, infant mortality was equal to 275 per 1,000 births, being higher than the proportion in England and Wales by 50 per 1,000.

Excluding the towns, infant mortality in the remainder of England and Wales was in the proportion of 184 to 1,000 births. *Diarrhoea* caused 22,524 deaths, equal to an annual rate of 2.85 per 1,000, or 1.21 above the average rate of mortality in the third quarters of the previous ten years.

The death-rate from this disease ranged from 0.7 in

¹ Quarterly Return of the Registrar-General.

Rutlandshire, 0·58 in Hertfordshire, 0·66 in Shropshire, and 0·68 in Dorsetshire, to 8·68 in Leicestershire, 8·70 in Staffordshire, 8·94 in Lancashire, 4·28 in the East Riding of Yorkshire, and 4·40 in Warwickshire. Among the thirty-three great towns the diarrhoea rate averaged 3·85 per 1,000, the highest rates being 5·85 in Hull, 5·94 in Sunderland, 6·30 in Sheffield, 6·38 in Wolverhampton, 6·41 in Preston, and 6·47 in Salford. In the sixty-seven other large towns the rate averaged 3·27 per 1,000. In the rest of England and Wales the diarrhoea death-rate was equal to 2·07 per 1,000.

It will be observed that the mortality from diarrhoea was mainly urban. Among counties it is the rural counties which have least and the industrial counties which have most diarrhoea, and if we turn to the mortality returns for those counties where diarrhoea was especially rife, we shall find the mortality greatest in the urban districts. It is a point not without interest to note that the diarrhoea death-rate and the fever death-rate in this quarter bore no relation to each other, and that, while the diarrhoeal death-rate was 1·21 above, the fever death-rate was 0·03 below the average for the corresponding quarter of the last 10 years. In the following table some figures are collected which show this very strikingly :

Table showing the Death-rates per 1,000 from Fever and Diarrhoea during the Third Quarter of 1898.

—	Fever	Diarrhoea
England and Wales	0·16	2·85
London	0·11	8·19
Wolverhampton	0·18	6·88
Leicester	0·18	5·84
Manchester	0·09	5·88
Preston	0·28	6·41

DIARRHŒA

(Diarrhoea is a disease of hot weather, when there is special liability to sour milk, rancid butter, stinking fish, high meat, and rotten fruit. Ballard thought that when the four-foot temperature of the earth reached 56° F. diarrhoea became common. Tomkins, of Leicester (Leicester is a 'diarrhoea town'), showed that the disease became common when the one-foot thermometer stood at 60°. Snow, of Buffalo, U.S.A., showed that in 1886-88 diarrhoea mortality was highest when the minimum atmospheric temperature attained its highest average range. The London statistics for 1887 and 1888 collected by Dawson Williams show a similar relationship between diarrhoea and a high average minimum range of temperature. Copeman considers it highly probable that the disease is due to 'microphytic processes' going on in the upper layers of the soil. This would afford an explanation of the fact that summer diarrhoea is especially a disease of cities having a polluted soil. Ballard's conclusions (as given by Copeman) were: "That the essential cause of diarrhoea resides ordinarily in the superficial layers of the earth, where it is intimately associated with the life processes of some micro-organism not yet detected, captured, or isolated. That the vital manifestations of such organism are dependent, among other things, perhaps principally upon conditions of season and on the presence of dead organic matter which is its pabulum. That on occasion such micro-organism, capable of getting abroad from its primary habitat, the earth, and having become air-borne, obtains opportunity for fastening on non-living organic material and of using such organic material both as nidus and pabulum in undergoing various phases of its life-history. That in food, inside of as well as outside of the human body, such micro-organism finds, especially at certain seasons,

nidus and pabulum convenient for its development, multiplication, or evolution. That from food, as also from the contained organic matter of particular soils, such micro-organisms can manufacture by the chemical changes wrought therein through certain of their life-processes a substance which is a virulent chemical poison (probably ptomaine). That this chemical substance is in the human body the material cause of epidemic diarrhoea."

It is most important to remember that these speculative notions of Ballard's are not facts.

The *Bacillus enteritidis sporogenes* is believed by Klein to be the cause of infantile diarrhoea.¹ It is an anaerobic bacillus which forms spores, and may be easily cultivated in milk. It is fatal to rodents when injected hypodermically, and produces a foul-smelling bloody œdema of the cellular tissue and adjacent muscle tissue. The spores were found in four out of ten cases of infantile diarrhoea examined, and in six out of eight cases of cholera nostras. It was found in eight out of ten samples of milk purchased in London milkshops between April and the end of June (when diarrhoea was not epidemic?) including samples of so-called 'pure sterilised milk.' It has been found in large quantities in sewage and in sewage effluents. It is found in horse-dung, and in all matters polluted with it. It has not been found in pig-dung or cow-dung, or in the dung of a healthy human being.

In face of the wide distribution of the microbe, it is evident that the vulnerability of the individual must be an important factor in determining an attack of diarrhoea. If we are to consider diarrhoea as a soil disease it is evident that it exists only in the upper layers. It is

¹ *Twenty-seventh Local Government Report, 1897-98.*

more common among city streets than in agricultural districts. According to Klein, the probable cause is largely to be found in horse-dung which is pulverised and blown about generally. Temperature, as we all know, is most potent as a cause of infantile diarrhoea in cities. That it is a 'soil' disease in any true sense is certainly not proven.

DYSENTERY

Andrew Davidson¹ says:—"In keeping with the predilection of endemic dysentery for marshy localities, accounts of its endemo-epidemic extensions in temperate climates generally point to the temporary establishment of paludal conditions." Thus in 1873 an outbreak arose from the cleaning out of the lateral canal of the Loire and the desiccation of the mud. A similar result followed at Leymen (Haut-Rhin) from the clearing out in August, 1850, of a vast slimy reservoir situated in the middle of the village. In tropical countries dysentery appears to be more independent of soil than in temperate climates, but an imperfectly-drained or marshy soil is everywhere favourable to its prevalence. The geological nature and the mineralogical constituents of the soil are secondary in importance to its physical conditions—its dryness, humidity, and aeration. These again are of less moment than its state of organic purity. That a soil charged with dysenteric or perhaps even with faecal (simple faecal) evacuations is capable of giving rise to the disease is amply proved. The epidemics which occurred in the Cumberland and Westmorland Asylum in 1864-65 and in 1868 were shown by Dr. Clouston to be in part due to the effluvia from a stiff clay field over which the sewage of the asylum was allowed to flow.

¹ *Allbutt's System of Medicine*, vol. ii. p. 408.

The soil was quite unfit for irrigation purposes. Dysentery is very common in asylums, a fact which is probably due to the infectivity of the excreta and the dirty habits of lunatics. Among the causes of the frightful dysentery mortality which made Secunderabad a byword, none was more effective than the saturation of the soil of the site itself with organic impurities, the extreme pollution of the vicinity with faecal matters, and the bad privy accommodation. The dysentery of war and famine shows little respect for climate or season; under the given conditions it appears in countries most free from the endemic disease, and at all seasons of the year. The dysentery of war and famine is extremely fatal, and it has a greater tendency than any other to become complicated with typhus, typhoid, and malarious fevers. In the Irish workhouses during the ten years ending June, 1851, no fewer than 50,019 persons perished from dysentery, and 20,507 from diarrhoea. The dysentery of war and famine frequently assumes a contagious character. The bacteriology is rather uncertain owing to the numbers and variety of the micro-organisms which are found.

Davidson concludes : (1) The healthy intestine is capable of much resistance to the infective agents of dysentery. (2) The healthy human being carries with him organisms capable under certain conditions of giving rise to inflammation of the intestinal tract, and besides organisms of suppuration, putrefaction, and sepsis are everywhere present which have the power of determining dysenteric inflammation of the bowels when their nutrition is impaired. (3) A simple catarrhal condition of the bowel is sufficient in itself to produce true dysentery. (4) When we observe a body of men seized with an infectious form of dysentery immediately after being subjected to hardship and depressing meteoro-

logical influences, while another body in the vicinity having the same food- and water-supply but not subjected to the like fatigue and hardships escape, we are led to infer that the common excitors of inflammation rather than any specific agent must have given rise to the disease.

CHOLERA

Ernest Hart says: 'Within certain areas in India cholera is endemic, especially in the country of the lower Ganges. There the air, the water, and the soil are never cold, the ground is often damp, and when it is dry the tanks are foul, so that there is always a fit breeding-place for the contagion, &c.' Koch's vibrio (Kanthack) grows in dilute peptone at from 30° to 85° C. It is commonly said to be destroyed by drying. It is a facultative anaerobe and highly saprophytic. Cultures retain their vitality on silk threads for eighty-six days and dried on glass for 120 days. "From flies fed on choleraic material the vibrios could be separated after fourteen days." The inoculation test practised on the lower animals is inconclusive. According to Pettenkofer (quoted by Copeman) cholera occurs when the ground-water after having attained a higher level than usual commences again to fall.

CHAPTER IV

MALTA FEVER—PLAGUE—DIPHTHERIA

MALTA FEVER¹ is caused by the *Micrococcus melitensis* discovered by Bruce in 1887. It is common to the shores of the Mediterranean and Red Seas. "It was early apparent that its presence in Malta and Gibraltar was connected with faecal and organic matter from human sources. Sewers and sewage works where these have been undertaken, as in Valetta and Naples, appear to have little influence in diminishing the attacks. Indeed, the channels are so frequently pervious and allow the faecal matter to soak into the pores of the soil that they virtually become elongated cesspools and increase rather than diminish the dissemination of the poison. Tomaselli notices the same fact in relation to the prevalence of the fever and the introduction of sewers into Catania. In his opinion the immense quantity of sewage and sewer air which is developed in these sewers and finds its way out of them is to be placed in the first rank of its causation and is an argument in favour of the aerial dissemination of the morbid agent. The micro-organism grows best in nutrient material the alkalinity of which is slightly less than human blood and at a temperature of from 87° C. to 89° C. It fulfils Koch's postulates at all points. It lives for a long time in the dry state."

¹ *Allbutt's System of Medicine*, vol. ii. p. 463, by Lane Notter.

PLAUE

(4) that the pulmonary form of the disease is terribly infectious and communicable through the air; and
(5) that measures of disinfection and isolation are capable of cutting short an epidemic. Experiments carried out in districts where a disease is epidemic or endemic necessarily acquire a measure of uncertainty from that fact alone. The occurrence at Vienna, much as one may deplore it, was an object-lesson of the greatest value and converted what many regarded as mere theories into facts which all can read and understand. In the recent epidemics in the East the theory that plague grows 'in the soil' has received no support whatever, and that it spreads in the soil like a drop of oil permeating paper appears to be unlikely. In India two facts have come to the front—viz. the danger in relation to plague of (a) rats and (b) abrasions on the skin.) The rat lives in burrows in the soil and swarms in our sewers. He feeds largely at night and comes out of his hole in search of food and prey. It has long been recognised that the rat is susceptible of plague. In Bombay, according to Simpson, as many as 100 affected rats were counted in one small grain dépôt in one day. Hindoo writings 800 years old warn the inhabitants to leave a district when they observe a mortality among rats. The infection of rats usually follows infection of a distant locality by men. Nowhere has this been more decidedly proved than during the epidemic in India, where the infection of the rats has unfortunately followed the introduction of the virus by man, from a primary seat of infection situated at considerable distances from the secondary area of infection. Rats may convey infection from infected burrows on their feet or fur; they also become infected by eating each other. When dying they usually leave their holes and run

about the rooms of a house and then die. Carelessness in dealing with or handling them, especially in the filthy surroundings and associated with the dirty habits of the inhabitants of these houses, along with the possible convection by vermin, must all necessarily be in favour of the infection being carried to man. The amount of such infection spread by rats cannot be gauged. The infection of the rat is no proof whatever of infection of the soil except by filth deposited on the surface. Lowson in his report to the Bombay Government in 1897 says: "That the disease is primarily a soil disease is certainly borne out neither by observation nor experiment. Takaki and I carried out bacteriological experiments in Hong-Kong by which we were able to prove that even in houses in which the earthen floors had been severely infected no cases of plague infection could be obtained, and later experiments on the artificial infection of earth with a culture of the plague bacillus have shown that the mixture of earth and bacilli loses its infecting power, sometimes in a couple of days." Indeed, there has been no proof forthcoming so far that the plague bacillus has ever been found below the surface of the earth.

In Hong-Kong the soldiers who were attacked by plague were in the cleansing squads, and were well booted, but worked with trousers open at the bottom. In India the military parties who assisted in this work were ordered to wear putties to prevent plague-infected dust and animals from coming in contact with their legs, with the result that none of those engaged in this work became infected, and that, too, amongst probably eight or ten times more soldiers than were doing the work in Hong-Kong. To sum up, it may be said that the following are the most important items in the spread

of plague : (1) filthy habits of the people, over the floor and others mentioned above houses ; (3) overcrowding and consequent of contagious disease when once imported of rats, insects, and other vermin ; (5) condition of the people going about, such persons having almost unlimited opportunities for their tissues of plague poison by inoculation through abrasions ; (6) pollution of soil and water by excretions of man and animals ; and (7) absence of bodily hygiene.

DIPHTHERIA

With regard to diphtheria, Arthur Newell work on 'Epidemic Diphtheria' (1898), that personal infection is the chief means by which diphtheria is spread, contends that: The micro-organism of this disease has a double cycle, as have the specific micro-organisms of erysipelas, scarlet fever, rheumatic fever. The saprophytic phase is passed in the soil, another parasitic organism. One is saprophytic, the other parasitic. It is not strange, therefore, that the epidemic of all the above diseases is favoured by damp weather if this is sufficiently long continued. Rainfall implies a low subsoil water and a high level of this water which is relatively constant, probably the optimum conditions of the life of the above pathogenic micro-organism. The course of the transition of the diphtheria bacillus from the saprophytic to the parasitic phase of life is as follows:

¹ It is not contended that there is a regular alternation between the saprophytic and parasitic generations; but that such alter-

mised both as regards (a) season and (b) years of special epidemic prevalence. Diphtheria is most prevalent in the autumn and early winter months, when the optimum temperature and the optimum degree of humidity of the soil are rapidly disappearing or have departed. It is also most prevalent after the wet weather, occurring in, or immediately following, exceptionally dry years. Both these conditions tend to raise the ground water and to drive out any pathogenic micro-organisms from the soil.

Newsholme is of opinion that in order to account for the epidemic and even pandemic waves of diphtheria, the diphtheria bacillus under certain conditions becomes more actively virulent and infective—more remote from its saprophytic phase of life, and that thus persons who can resist the ingress of the feebler fall victims to the more powerful micro-organism. The latter is probably the correct hypothesis, and the evidence already given clearly points to the conclusion that of the external cultural conditions leading to increased virulence of the diphtheria bacillus and greater readiness for assuming a parasitic life, exceptional deficiency of rainfall and consequent exceptional deficiency of moisture in and exceptional warmth of the subsoil form an essential part.

The above is a very ingenious hypothesis, but it is essential to point out that the diphtheria bacillus has not been recovered from the soil and that the bacilli of rheumatic fever and scarlet fever have not yet been identified.¹ Before Newsholme's hypothesis can be accepted a great deal more evidence will be necessary.

¹ Poynton and Paine have isolated a diplococcus in rheumatic fever, which may turn out to be the specific micro-organism. (*Path. Trans.* vol. lii. 1901, p. 10, and other papers.)

Newsholme's figures and tables show clearly that the amount of diphtheria is very great in the American cities. He records death-rates (per 100,000) for diphtheria of 109 in New York (average of 28 years, 1868-95), 77 in Chicago (36 years, 1859-94), 100 in Boston (35 years, 1861-95), 114 in Brooklyn (1875-95), and 129 in Pittsburg (1877-94.) The highest death-rate from diphtheria ever recorded in London was 76 (per 100,000) in 1898. The average death-rate per 100,000 was in Salford 32 (1860-95), Manchester 18 (1871-96), Liverpool 14 (1860-95), and Sheffield 15 (1859-96). The figures were still lower in others of our great industrial towns. In Holland we find death-rates per 100,000 from diphtheria alone of 7 in Rotterdam, 12 in The Hague, and 31 in Amsterdam (all three for 1879-95). Berlin gives 101 (1869-96), St. Petersburg 65 (1879-95), and Moscow 64 (1878-96). The death-rate in Japan appears to be low.

Newsholme's figures generally seem to show that diphtheria is now a disease more of the towns than of the rural districts. It is not very easy to understand how in a city where pavements and other impermeable coverings to the soil are general, the bacillus is driven by the rising subsoil water into the air. Of course, it may be driven out of the sewers and sewer ventilators, in which case it becomes a sewer disease rather than a soil disease. Why is it not an air disease? Nobody who has ever smelt the air of Bond Street in a hot July, or who has watched the impurities descending from the upper air when they are driven downwards by the first showers after a drought, would refuse to allow to the air of a city any amount of potential infectivity. Most of the facts collected by Newsholme are explained as readily, if not more readily, on the theory that diphtheria is an

air disease as upon the theory that it is a soil disease. If we remember that a theory is not a fact these speculations will do no harm. Unfortunately this is not always remembered. Diphtheria (Copeman) has been supposed to show a preference for houses on damp clayey soils (Greenhow, Airy) and dampness of habitation (Thursfield). "Although," says Copeman, "dampness of site is undoubtedly a factor in the production of outbreaks of diphtheria, particularly if such dampness be due to persistent leakage from imperfect sewers or cess-pools," it does not appear to bear any relation to the rise and fall of the subsoil water.

That diphtheria is a soil disease is certainly not proven.

CHAPTER V

**MALARIA—BLACKWATER FEVER—TSETSE—LOUPING
ILL—TEXAS FEVER—HORSESICKNESS**

A FEW years ago I should have spoken of 'malaria' as undoubtedly caused by something in the soil itself, and I should have indulged in the stock phrases about miasmata, mephitic vapours, and the like. The discovery of haematozoa in the blood of sufferers from malaria has altered our point of view. The most widely spread poison in the world has become something which is visible and tangible and inoculable. No discovery which has ever been made in the domain of medicine is likely to have such far-reaching effects. Further, it seems certain that the infection of human beings may take place *via* the mosquito, and we are now concerned to find out whether this is or is not the only medium through which the blood of man receives the parasite. Some who are well qualified to speak would answer in one way and some in another. This is not the place for weighing arguments *pro* and *con*, nor can I claim any special knowledge which qualifies me to sit in judgment. Let us assume that it may possibly be shown hereafter that what we have hitherto regarded as 'malaria' is a parasitic disease wholly and solely inoculated in us by insects of the mosquito class. While on the one hand we may be able to show Europeans the importance of

protecting themselves against the attacks of insects, we must still continue to make use of our accumulated knowledge as to the conditions of soil which indirectly cause remittent fevers to be endemic, and which favour the increase or decrease of mosquitoes by facilitating or otherwise the formation of breeding pools. Old and well-established facts will now be re-examined by intellects strengthened and widened by the discoveries of Laveran and Ross, and our knowledge is sure to be extended and increased.

Although the conditions of soil which give rise to malaria are too well known to need any lengthy discussion here, it may be well to give some of the latest utterances on the subject.

Sir Joseph Fayrer, writing on the 'Climate and Some of the Fevers in India,' in 'Allbutt's System of Medicine,'¹ says of malaria: "It often appears with great virulence after excavation or turning up of soil, and in land that has recently been denuded of jungle." . . . "On the other hand, draining and cropping seem after a time to diminish or destroy the poison. Maclean calls attention to the fact that when excavations were made in the island of Hong-Kong, which consists entirely of weathered and decaying granite, and is liable to be permeated with a peculiar fungus, violent and fatal remittent fever appeared."

Osler says: "An interesting feature in connection with the disease is the gradual disappearance from certain regions under the influence of drainage and cultivation. In England, even in the fen country, it is now almost unknown. In New England, too, it has gradually disappeared. In parts of Canada bordering Lake Ontario which were formerly hotbeds of the

¹ Vol. ii. p. 311.

disease cases only exceptionally occur." It is well called a soil disease. "Excavations of all sorts, extensive cuttings for railways, and the breaking up on a large scale of virgin soil have in many instances been followed by outbreaks of malaria."¹ The greater prevalence of fever in the Royal Engineers in comparison with other troops is probably to be accounted for by their more frequent employment in the excavation of the soil. Manson,² speaking of Ross's work in connection with the mosquito, says that although he believes that malaria may be acquired by the bite of the mosquito, he does not believe that this is the only way. Rees,³ of the Seamen's Hospital, gives details of an outbreak of intermittent fever (confirmed by examination of the blood by himself and Manson) which affected twenty-two of the crew of a ship nine days out from Colombo and fourteen from Calcutta on her homeward voyage. Air-borne infection or water-borne infection cannot be lightly dismissed.

As to blackwater fever, Crosse, writing on the subject,⁴ says: "Some will ask, Why has blackwater fever become so common recently? The first case on record in the Niger Territory was, so far as I know, my own, ten years ago. The first case on the Niger Delta is said by some old coasters to have occurred in 1882. It seems to me that since we have begun to turn up virgin soil for coffee and other plantations the disease has become common. . . . It is significant that our first three gardeners died of blackwater fever, and

¹ I recently discussed this subject with two gentlemen who were intimately connected with Indian railways, and who professed ignorance of any danger arising from recent cuttings.

² *Brit. Med. Jour.* Sept. 24, 1898.

³ *Ibid.* Sept. 24, 1898.

⁴ *Ibid.* Oct. 8, 1898.

that for some considerable time cases only occurred near the plantations, and as plantations became common so the disease spread to the other stations in the territories. Castellote notes a case in which a white man personally superintended the digging of a grave and stood about in the sun for two or three hours; next day he had severe fever which developed into blackwater fever." According to Battersby, "many virulent attacks after the turning up of virgin soil have been recorded." Almost equally remarkable, according to this observer, is the diminution of the disease which has been brought about in certain localities by drainage and cultivation of the soil.

It is generally conceded that the turning up of virgin soil is one of the most fruitful causes of malignant malarial fevers, and numberless examples of this are given in text-books on the subject. Surgeon Bowden, R.N., D.S.O., informs me that the turning up of fresh soil is often followed by an influx of mosquitoes. On the other hand, the cultivation of the soil seems ultimately to lead to the decrease and disappearance of malaria. The broad facts of Nature must convince us that this must be so, for if man in his attempts to grow food merely increased the deadliness of his surroundings, the human race would soon become extinct.

There is a group of diseases which (like malaria) seem to be dependent upon the bites or stings of insects, and which, although they affect animals rather than man, throw much light upon the pathology of infection, and teach us that so-called 'climatic diseases' may be due to something very gross and palpable.

TSETSE FLY DISEASE

Kanthack, Durham, and Blandford¹ have shown that Ngana or tsetse fly disease is due to a haematozoon (*trypanosoma*) in the blood inoculated by a fly. Cats, dogs, mice, rabbits, rats, hedgehogs, donkeys, horses, and their hybrids seem susceptible. The disease appears to be communicable only by some form of inoculation and is not probably conveyed by feeding on infective material in the absence of superficial lesions. Material taken from the dead body twenty-four hours after death is not infective. The nearest lymphatic glands to the inoculated spot are the first to suffer. The haematozoon gets through the lymphatics to the blood. In the late stages of the disease the animals (especially dogs) may become infected by pyococci, i.e. a spontaneous infection to which the animal is rendered prone by its marasmus. The blood may contain 3,000,000 haematozoa per millimetre, or may prove infective though none be visible. The *trypanosoma sanguinis* which is found in a certain proportion of rats has no apparent relation to tsetse fly disease. A similar parasite is said to cause 'surra' in India and an allied disease among horses in Algeria. Surra is probably conveyed by flies. Lingard thinks the fodder soiled with rat-dung may give the disease, but that is doubtful. The tsetse fly is a dipterous insect somewhat resembling the common house fly. It has a long thin proboscis, chestnut thorax marked longitudinally by four black lines, and a yellowish-white abdomen of five rings. It inhabits principally the low-lying and swampy valleys of the Zambesi and Chobe.

¹ *Proceedings of the Royal Society*, vol. lxiv. p. 100.

LOUPING ILL

'Louping ill,' which is common in the North of England and Scotland, and which has been noticed as fatal to sheep frequenting certain pastures, has now been shown by Williams, Meek, and Greig Smith¹ to be caused presumably by a special kind of sheep 'tick' found on these pastures, which tick is supposed to be hatched in the upper layer of the soil, and to inoculate the sheep with micro-organisms which cause the disease—a disease which is characterised by staggering and lameness, due to congestion of the brain and spinal cord, which have been found post mortem.

TEXAS FEVER

Texas fever of cattle appears to be caused by a *haematozoon* with which the animal is inoculated by a tick (*ixodes* or *boophilus bovis*) which is parasitic. The Australian tick fever and the ixodic anaemia of Jamaica appear also to be produced by allied if not identical parasitic animals. Principal Williams, F.R.C.V.S., of the New Veterinary College, Edinburgh, in writing on ixodic anaemia or Texas fever² (which he studied in Jamaica), which is due to the infection of cattle with a blood parasite by the agency of a tick (*ixodes bovis*), insists that every attempt should be made to get rid of the ticks, which breed especially in the vegetable rubbish left upon the pastures. "Every effort should be made," he says, "to conserve and increase tick destroyers such as the black tick birds. . . . I have had much amusement in watching these birds, as there seems to be

¹ *Veterinarian*, 1896-97.

² *Principles and Practice of Veterinary Medicine*, p. 416 *et seq.*

an understanding between them and the cattle whereby they are assisted and encouraged to destroy the ticks. Domestic fowls should be encouraged, and starlings and song-thrushes might be imported. To a stranger visiting the island (Jamaica) the scarcity of birds is a striking feature. I have been told that it is due to the mongoose, which has not only diminished the number of wild birds and domestic fowls, but other tick-destroying creatures such as the ground lizard. Now this destruction of the natural tick destroyers should, as far as possible, be prevented, firstly by legal protection, secondly by encouraging the slaughter of the mongoose." (For further remarks see *Veterinary Journal*, 1896.)

AFRICAN HORSE DISEASE

South African horse disease has no apparent connection with insects or surface wounds, but appears to depend, not upon conditions of the surface soil, but on temporary conditions of the vegetation which forms the pastures.

South African horse disease (œdema mycosis) is described by Captain Hayes, F.R.C.V.S., in his translation of Friedberger and Fröhner's 'Veterinary Pathology,' and is supposed by Edington to be caused by a mould (*penicillium*) which grows in the vessels, causing thrombosis and exudation of serum, with fatal results. It appears to occur chiefly among animals which are allowed to graze while the dew is on the grass, and the growth of the microbe is supposed to be connected with the dampness of the grass. The disease, once contracted, is almost always fatal, but the prophylactic appears to be dry fodder and the folding of horses until the sun has dissipated the moisture of the dews.

The history of those diseases which appear to depend on inoculations points with no uncertainty to the advisability of keeping a whole skin. The 'verminous person' has assumed an importance in relation to the public health which the Legislature has already recognised, while the 'tramp,' with his special liability to small-pox, is one to whom the anti-vaccinationist is likely to discover a 'conscientious objection.' The special liability of the 'tramp' to suffer from small-pox—if such is really the case—seems to offer a field of investigation well worthy of being methodically explored.

There are other diseases more or less suspected of being soil diseases, but the facts are at present too few to make any discussion profitable. These are yellow fever, beri-beri, swine fever (undoubtedly propagated by fouling of the surface soil), cancer (?), threadworms, hydatids, and *Ankylostomum duodenale*. Malignant œdema is an infective disease of wounds undoubtedly caused by a ubiquitous anaerobic saprophyte, which occasionally manages to grow in the cellular tissue and to generate gas (CO_2 , H_2 , H_2S , CH_4) therein.

CHAPTER VI

ENTERIC FEVER

ENTERIC fever has of late years much occupied the attention of epidemiologists and bacteriologists, and our knowledge of its definite relationship to filth, milk, and water has undergone considerable increase. The laboratory experiments connected with enteric fever are of great interest and value, but it would be, to say the least, hazardous to build upon them any measures intended for practical sanitation. It must never be forgotten that the typhoid bacillus does not fulfil one of Koch's postulates. The disease produced by the inoculation of guinea-pigs with pure cultivation of typhoid bacillus has but a remote resemblance to the disease which we clinically know as enteric fever, a disease which seems limited to the human species. Sidney Martin¹ found that "none of the ordinary cultures of the typhoid bacillus obtainable in the laboratories will kill an animal," but that it may be rendered virulent by inoculation and transference through a succession of peritoneal cavities, and also by

¹ Croonian Lectures, 1898.

² When therefore Sir Richard Thorne in commenting upon Martin's pure cultivations of *Bacillus typhosus* in sterilised soil says that they yielded the bacillus 'presumably in virulent phase' (*Local Government Board Reports*, 1897-98, p. 23), his presumption is scarcely warranted by the facts.

injecting simultaneously the products of other micro-organisms, such as streptococcus or *Bacillus coli communis*." It is noteworthy that the *Bacillus coli communis* and Gaertner's bacillus when subjected to similar manipulations are as toxic to rabbits as is the typhoid bacillus. It must be remembered that 'pure cultivations' of the *Bacillus typhosus* cannot be said to exist in nature. ! We recognise, and it may be taken as proven, that the main cause of the endemicity and epidemicity of enteric fever in this country is to be found in the faeces of the patient, and yet Martin tells us that while the bacillus is invariably found in the spleen and mesenteric glands and in intestinal lesions, "it is found in some cases in the motions of typhoid fever and also in the urine." Dr. J. R. Carver, working under Delépine at Manchester, found the typhoid bacillus twice in twenty samples of typhoid faeces and once in sixteen samples of typhoid urine.¹ Osler records sixteen instances of bacilluria in fifty-one cases (1900-1901) and states that "bacilli may be present in the urine for years after the attack."

Martin, working with sterilised soils, has shown that in soils which are more or less 'polluted' with organic matter the *Bacillus typhosus* will continue to live and spread at ordinary temperatures, but that in virgin soils (both sandy and peaty) the pure cultivations of the bacillus die out from some unexplained cause. Martin gives one experiment² to show that in unsterilised soil containing much organic matter the bacillus may continue to live, but as yet there has been no evidence of spreading. The results recorded in the same observer's more recent paper are that typhoid bacilli will grow and live for a long time in sterilised

¹ *The Lancet*, August 20, 1898. ² *Local Government Report*, 1897-98.

soils, but rapidly die out in unsterilised soils, being overpowered by the bacilli present in the soil.) (See 27th (1897-98), 28th (1898-99), and 29th (1899-1900) Annual Reports of the Medical Officer to the Local Government Board.) John Robertson and Maitland Gibson¹ collected thirty samples of soil from areas which they considered likely to be infected. "In not one single instance was the *Bacillus typhosus* found."

These gentlemen carried out experiments in a field (soil, eight inches of clayey loam on ten inches of sand and clay on stiff yellow boulder clay); each experimental patch had the turf removed and nothing was allowed to grow upon it. The patches were eighteen inches square. Three patches were inoculated with 200 cubic centimetres of a pure cultivation of the *Bacillus typhosus* mixed with one and a half gallon of tap water—No. 1 on the surface, No. 2 nine inches deep, and No. 3 eighteen inches deep, the top soil being removed and replaced. This was done on May 30, 1896, and on August 26 the *Bacillus typhosus* was found three inches below the surface of each, and at nine inches below the surface of No. 2 and No. 3, and also at eighteen inches below the surface of No. 3. On October 20 there were practically the same results. On November 27 the *Bacillus typhosus* could not be found in either patch. Towards the end of August, 1896, three other patches (Nos. 4, 5, and 6) were inoculated in the same way, and on November 27 no *Bacillus typhosus* could be found. These patches were three feet square. On January 17, 1897, patches No. 4, 5, and 6 received two gallons of very weak beef tea, which was repeated at fortnightly intervals till June 3, 1897, when on examination the organism was easily found. No organism was found at this date in patches Nos. 1, 2, and 3, which had not

¹ *Brit. Med. Jour.* January 8, 1898.

EXPERIMENTAL

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been fed with bouillon. Practically the same result was obtained on July 11. The persistence of the *Bacillus typhosus* appears to depend on feeding it with fluid nourishment. A sewer leaking into the soil would do this, or liquid filth in a privy. It was shown that the organism would grow three inches downwards or upwards from a depth of eighteen inches. The slight downward growth might be due to mechanical conditions. The effect of sunlight does not penetrate far.

Laboratory experiments went to show that vegetation (grass) prevented the growth of the organism. This may go to explain 'why typhoid fever is so much more prevalent in towns than in rural districts.' Attempts to prove the aerial conveyance of the organism from liquid filth failed.

Further allusions by Dr. J. Robertson to these experiments were made later in the year,¹ in the course of which he said : "During the winter months organisms disappeared from the surface soil, and from these experiments I was led to believe that the deeper layers acted as a sort of shelter during the winter months, from which the organisms sallied forth to the surface during the warmer months." He had not noticed any relation between typhoid fever and the rise and fall of the ground water, but he thought it was most common in places where the ground water is near the surface. The *Bacillus typhosus* quickly dies out in grass-covered areas.

Let us now turn from these experiments, which, after all, are very artificial, to the practical experiences of sanitarians in the matter. It may be premised that Martin's experiments show that the *Bacillus typhosus* will grow in any soil rich in organic matter, and that although aerobic it can be cultivated as an anaerobe

¹ *Brit. Med. Jour.* August 18, 1898.

even in an atmosphere of carbonic acid,¹ and the bacillus seems to be definitely destroyed by sandy or peaty 'virgin' soils. Robertson and Gibson cultivated the bacillus on a soil in which clay predominated. Sir Charles Cameron is of opinion that it flourishes in gravel. At Dublin on August 23, 1898, he said, speaking of enteric fever: "That there is a connection between enteric fever and the soil is shown by the results of observations of the distribution of more than 4,000 cases of the disease in Dublin. Where gravel forms the site of streets there is far more typhoid fever than in districts which rest upon the stiff boulder clay. This is clearly owing to the fact that the *Bacillus typhosus*, which is *aerobian*—that is, requires oxygen—can get it more freely in the loose gravels than in the stiff clays. In the gravel, too, there is a much greater space for the development and movement of the bacilli."

Dr. Scurfield, of Sunderland, said that "the greater part of the county of Durham in which typhoid fever had been prevalent during the last few years was covered with stiff boulder clay, and in the urban district of Sunderland typhoid fever had been just as prevalent in the boulder clay as in the houses built on sand or gravel." The late Professor Pettenkofer, of Munich, is mainly answerable for the theory that enteric fever is due to a soil organism which grows with maximum vigour when the level of the ground water falls.

Dr. Christopher Childs, in a valuable paper which appeared in *The Lancet*,² has placed us in possession of important facts. Munich lies on a bed of gravel 1,700 feet above sea-level. Between 1851 and 1896 the population had increased from 124,000 to 412,000, so

¹ *Local Government Board Report, 1867.*

² *The Lancet, February 5 1898.*

that modern Munich is largely a new city. Up to 1865 Munich was a city of soak-away cesspools and filthy surface wells, and it was not till 1858 that the cesspool system began to be remedied, and not till 1865 that the water-supply began to be improved. Pettenkofer's early investigations, Dr. Childs says, led him to the conviction that in Munich there was not the slightest connection between the drinking-water and the typhoid,¹ and this in spite of the fact that the water was shown on analysis to be organically polluted. The analyses and general investigations of the earlier date have been very imperfectly recorded, but there is evidence, says Dr. Childs, that the water was much worse in the earlier periods than latterly. Of Pettenkofer's personal investigations Dr. Childs says: "I have not succeeded in finding recorded details, but they derive their weight from the high authority of Pettenkofer himself." The enteric death-rate, which (per 100,000) was 202·4 for the decade 1851-59, fell to 147·8 in 1860-69; to 116·7 in 1870-79. In 1880 it was 72; in 1881 it had fallen to 18 and has not risen since.

The water in Munich is derived from the mountains, and when these are covered with snow the subsoil water falls. It is a most interesting fact to note that Pettenkofer's Munich typhoid fever was a disease of winter. The incidence of the Munich typhoid fever between the years 1851-67 was, according to Pettenkofer, in monthly averages as follows:

February . . .	86·8	April . . .	23·1	September . .	16·1
January . . .	88·5	November . .	19·0	July . . .	15·8
March . . .	31·8	May . . .	17·6	June . . .	15·2
December . . .	28·5	August . . .	16·7	October . . .	15·0

¹ This may have been due to the fact that the wells were all equally bad.

The average English sanitarian reading this account of Munich with its soak-away cesspools and foul drinking-water would not need any new theories to account for the prevalence of typhoid fever. If we accept Pettenkofer's theory that the fever was due to organisms in the subsoil, it is interesting to observe that the Munich fever, unlike typhoid fever in other places, reached its maximum in February, and was most rife in the coldest weather when the surface of the ground must have been often frozen. During the winter months, when the big houses were closed and the stoves were lighted, the interior of the houses must have been filled with cesspool air. An organism permeating the soil might be expected to die out gradually. The sudden fall of the death-rate from 72 in 1880 to 18 in 1881 seems to imply that the organisms suddenly died over the whole area of the city. Munich is a city in which the general sanitary condition has undergone gradual amelioration. Sewers on modern lines were begun in 1878, and 800 private slaughter-houses were destroyed in the same year. There is now a highland water-supply and typhoid fever has gone. But it is needless to say that the subsoil water rises and falls precisely as it did half a century ago. The connection of typhoid fever in Munich with organisms growing in the soil is to my mind not proven.¹

In 1896 there were 111 cases of enteric fever at Chichester, of which the majority occurred in July and

¹ Ziegler (in 10th ed., 1901, of his *Allgemeine Pathologie*, vol. i. p. 89) refers to Pettenkofer's view that the soil influences the virulence of the micro-organism by communicating a something to the latter under certain conditions, but adds that recent research on the etiology and spread of typhoid fever, cholera, and plague has not lent any support to such an hypothesis.

August, and of which only two died (one committing suicide while delirious). Seventy-six houses were attacked in localities which had been repeatedly invaded in former years. Of these houses thirty-nine had well-water (quality doubtful), and thirty-six had company's water. In sixty-two of the cases the patients were males and in forty-nine they were females. There had been recent works of drainage, and it was found that the percentage of incidence of fever on the whole of the undrained houses of the town was slightly in excess of that of the drained houses. There was no evidence that the disturbance of the soil in this ancient walled city for works of drainage had influenced the incidence of fever. Many of the houses attacked had old privies, &c., and the back yards were soaked with organic matter. Enteric fever, as usual, showed a preference for filthy surroundings. This outbreak has been spoken of as due to the growth of the *Bacillus typhosus* in the soil round the houses attacked, but the evidence is certainly not conclusive, and the fact that the women who mind the house suffered less than the men is rather opposed to such a theory. The epidemic, which departs somewhat from ordinary epidemics in the time of its maximum virulence and its very low mortality, remains unaccounted for. Chichester is built on a bed of gravel. (The facts as to this epidemic are culled from Dr. Bulstrode's report to the Local Government Board.) In 1898, seventy-six houses in Chichester were again infected with enteric fever. Of these fifty-eight were 'drained' and eighteen 'not drained'; forty-four consumed town water, while thirty-two had well-water. Mr. Jones, the medical officer of health, points out that the percentage of incidence was markedly in excess

in the 'well-water' houses and slightly in excess in the 'undrained' houses.

Enteric fever has long been regarded as a filth disease, and there is abundant evidence that filthy surroundings in some way or other predispose to it. Waterlogged privies soil-sodden with the leakage of sewers, the air of cesspools and traps, proximity of water-closets to the kitchen, and other conditions of filth are all bad. While we agree as to the fact we may differ as to the explanation. Some would assert that the *Bacillus typhosus* is actually growing and spreading in the filth, and indeed that is possible, but direct evidence of it is wanting. Some would even say that the soil being inoculated the specific organism may continue to grow and spread in it far away from the point of inoculation, and so (by growth, not irruption) may poison the local water at a distance. Of this there is positively no evidence whatever. If for the sake of argument we allow that the *Bacillus typhosus* may grow in the soil we have to ask how it emerges from the soil to do us harm. We are here confronted with contradictions. Robertson and Gibson showed that the bacillus disappeared in the winter to reappear in the summer, while at Munich the increase of enteric fever was a phenomenon of midwinter. In Budapest it is associated with a rising ground-water, and at Munich with the opposite condition. In this country it is a disease of autumn and the period of floods, while others assert that it may be conveyed by dust, which ought to produce a prevalence in March. The opinions held by sanitarians and bacteriologists on this question differ widely, but there seems to be a consensus of opinion that a waterlogged soil rich in organic matter is the one in which the *Bacillus typhosus* is most likely to

flourish. If this should be true the official position that in sewage treatment filtration through earth is a *sine qua non* becomes untenable.

In the discussion which followed a paper which I had the honour of reading before the Royal Medical and Chirurgical Society in November, 1898, on the Prevention of Enteric Fever, and which has been published in vol. lxxxi. of the Transactions of that Society,¹ many eminent sanitarians and bacteriologists made most valuable statements. Sir Richard Thorne said, p. 56: "I do not think Nature made any provision for the disposal of specific excreta. Nature provides an easy means of dealing with the ordinary healthy excreta of healthy people living on the land, but dangers arising from specifically contaminated excreta are, I fear, much more difficult to be thus got rid of."²

The danger from flies is, in Director-General Jameson's opinion, a very real one in tropical countries. By their agency faecal poisons are probably carried to the food or milk. Dr. Sims Woodhead said: "We stand in need of further information in respect of the continuance of the typhoid bacillus in soil. I agree . . . that the typhoid bacillus has a much greater chance of persistence in a waterlogged soil containing a moderate amount of organic matter than in a dry, well-aerated soil, however large an amount of organic matter it may contain. In this, however, my actual experience is limited, though I hold a strong opinion on the subject." When we consider that the bacillus of typhoid fever may remain in the intestine for some time after

¹ This paper will be found on p. 185 of this volume.

² This opinion is not quite in harmony with Sidney Martin's repeated demonstrations that the *Bacillus typhosus* is killed by virgin sand or peat, and the death of it in Robertson and Gibson's soil which had not been watered with beef tea, and its extermination by growing grass.

recovery as well as in the urine and gall-bladder, and when we also remember what Metchnikoff pointed out in relation to cholera, viz. that the vibrio may be present in the intestine a long time before an attack of cholera occurs, it would seem that we can have typhoid bacilli under very similar conditions present in the intestine in practically healthy individuals, and that this bacillus may remain in the intestine a considerable time before the intestinal tract becomes so altered that the bacillus has a chance of doing its special work. Then it is that bad, though not actually infected water, may help the typhoid bacillus to do its work.

Dr. Corfield insisted on the importance of sewer air and cesspool air as factors in producing the endemicity of enteric fever. He instances Lyons as a city in which cholera has never spread, but in which typhoid fever is endemic. Lyons is a city of cesspools.

Loesener, in a paper¹ on the 'Viability of Pathogenic Bacteria in Interred Corpses,' states that he injected into the vessels and cavities of dead pigs a great quantity of pathogenic bacteria so that their number should exceed that of the saprophytes. In the first experiments the animals were not interred, and under these conditions the viability of the bacilli of typhoid fever and cholera did not exceed four or five days. When the animals were treated in this way and buried in a porous soil the pathogenic bacteria manifested a maximum viability as follows: Typhoid fever (one instance only) ninety-six days, cholera twenty-eight days, tubercle ninety-five days, *Bacillus pyocyaneus* thirty-three days, pneumo-bacillus of Friedländer twenty-eight days, *Micrococcus tetragonus* twenty-eight days, and tetanus 361 days (showed com-

¹ *Arbeiten aus dem kaiserlichen Gesundheitsamte*, vol. xii. f. 11, p. 448.

plete virulence after 284 days). The *Bacillus anthracis* preserved its complete virulence during the whole year of the experiment, and the bacillus of *rouget du porc*¹ and septicæmia of mice 284 days. As for the typhoid bacillus, it was possible to isolate it from the buried corpses *only once*. 'I believe,' he says, 'with Koch that the value of Pfeiffer's reaction of immunity is relative, and that outside the human body it is not in our power to identify the typhoid bacillus.'

Loesener's conclusion is that cemeteries are not harmful (even when graves made in a permeable soil are liable to inundation either temporarily or permanently) provided the graves be surrounded by a layer of earth sufficient to filter the liquids traversing them.²

¹ Robin, in *Nouveau Dict. Abrégé de Médecine*, &c. 1886, states that *rouget du porc* is, according to some observers, anthrax in the pig, to others typhoid fever of pig (Pasteur). In Hayes's translation (1898) of Friedberger and Fröhner's *Veterinary Pathology*, vol. i. p. 75, swine erysipelas is given as the equivalent of *rouget du porc*.

² From *Annales d'Hygiène Publique et de Médecine Légale*, troisième série, tome xxxvii janvier 1897.

CHAPTER VII

THE MAIDSTONE EPIDEMIC

THE epidemic of enteric fever in Maidstone in 1897 is of great importance in relation to the influence of the earth on contagion, and the report to the Local Government Board by Mr. J. S. Davy, Dr. T. Thomson, and Mr. G. W. Willcocks has put us in possession of most of the essential facts.

The date of the attacks (the notifications were later) in the town and in the County Lunatic Asylum as given in Table I. of the report were as under :

TABLE I.

	Week Ending	Borough	Asylum
September	4, 1897	29	—
"	11	165	1
"	18	484	18
"	25	482	48
October	2	274	12
"	9	184	15
"	16	64	4
"	23	45	2
"	30	33	4
November	6	25	2
"	13	28	1
"	20	19	—
"	27	18	—
December	4	4	—
"	11	5	—
"	18	3	—
"	25	2	—
January	1, 1898	3	—

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It was conclusively shown that the outbreak was due to the pollution of a spring or springs belonging to the Farleigh water-system. Of persons drinking this water nearly 8 per cent. were attacked, while of those drinking water belonging to other systems of supply less than 1 per cent. were attacked. The Farleigh springs, which are fifteen or sixteen in number, crop out on both banks of the Medway (mainly on the left bank) where the overlying and permeable green sand (locally known as 'ragstone') rests upon the impermeable clay beneath. The water of these springs is for the most part pumped to the Barming reservoir, whence it is distributed mainly to the higher parts of the town. The Farleigh springs yield collectively over 3,000,000 gallons a week, and they were treated collectively, and their waters were all mixed in one reservoir, holding 500,000 gallons, before distribution. That this reservoir and the pipes connected with it became polluted with enteric poison was beyond doubt, but it was not quite so clear which of the contributing springs was at fault. When, however, the springs were examined on September 19, one and one only was found to be dirty, viz. the spring known as 'Tutsham-in-Field.' In order to condemn this spring, which yielded only 85,000 gallons per week, both chemical and bacteriological analyses were wholly superfluous, and accordingly it was cut off from the supply on the following morning, September 20. This spring was reported as still dirty a month later, and when I saw it on November 5 it was still turbid, and manifestly unfit for drinking purposes.

'Ragstone' is often fissured, and there had been experiences in the Borough of Maidstone of the pollution of an old municipal supply known as 'the Conduit,' and of a well known as 'Hill's Well,' by leakage of sewage

from broken pipes and similar well-understood causes. Bacteriological investigations were made by Dr. Washbourn and Dr. Durham on behalf of the corporation, by Dr. Sims Woodhead and Dr. Cartwright Wood on behalf of the water company, and by Dr. Tew and Mr. Foulerton on behalf of the rural authority. The first four were all agreed that Tutsham-in-Field water afforded evidence of animal pollution on September 19 and 20, and the last two found similar evidence in the mixed Farleigh waters taken at Barming on September 22. It is noteworthy, and of very great importance, that diligent search was made for the *Bacillus typhosus* by the six eminent bacteriologists engaged, but without success. The situation of the Farleigh springs was such as to render them liable to pollution, and on chemical grounds they were open to suspicion, but only one of them (Tutsham-in-Field) was really convicted of animal contamination and was obviously dirty and unfit to drink. The facts of the epidemic are, I think, quite consistent with the theory that it was caused by pollution of the spring at Tutsham-in-Field.

The Tutsham-in-Field spring derived its immediate supply from the underdraining of a hop garden, and a reference to the diagram will show that its natural flow was assisted by some 20 feet of earthenware pipes, with open joints, which lay immediately on the Atherfield clay, and at a depth below the surface which varied from 2 feet near the catch-pit to 4 feet at the end which was farthest in the hop garden (*see fig. 1*). Immediately above the spot where the open pipes are nearest to the surface was a fence made of stakes driven into the ground, which may have served as direct conducting channels down to the open-jointed pipes. (Parenthetically, I would remark that the danger of a dead fence in

such a connection is much greater than a hedge with living roots.) Close to this fence were deposits of faeces. The line of the spring occupies a slight depression in the



TUTSHAM IN FIELD

FIG. 1.

ground, and the natural surface drainage must have been to a spot very close to that at which the collecting pipes were shallowest. This spot was only a few yards from a path which crosses the hop-garden fence by means of a stile, and in short the circumstances were



TUTSHAM IN FIELD

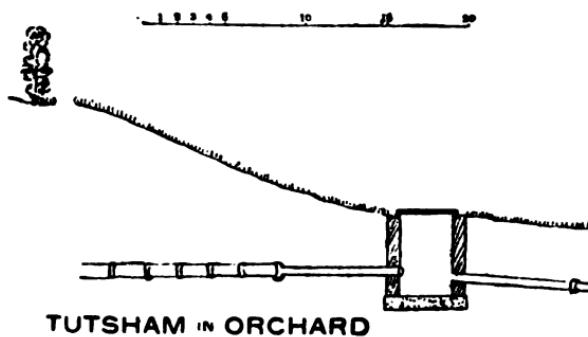
FIG. 2.

such that the risk of befoulement of the ground close to the collection pipes was very great¹ (*see fig. 2*).

If the diagrams at Tutsham-in-Field be compared

¹ In his report to the Local Government Board Mr. P. Adams speaks of this fence as a 'hedge,' but both the photograph and the plan show that it was a 'fence.' The point is not unimportant when the tendency of fences to rot at the foot is considered.

with those of Tutsham-in-Orchard and Ewell (figs. 3 and 4) it will be observed that earthenware pipes with open joints are used in all of them, but while in the



TUTSHAM IN ORCHARD

FIG. 3.

first-named these open joints came to within 2 feet of the surface, they did not come nearer than 5 feet at Tutsham-in-Orchard and 14 feet at Ewell. The surface

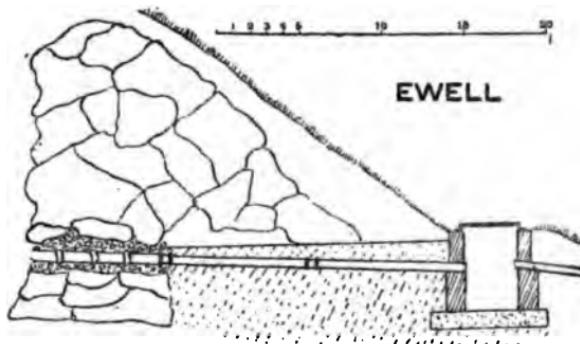


FIG. 4.

of the ground above the pipes was formed of turf at Tutsham-in-Orchard and Ewell. The Tutsham-in-Orchard spring was bright and apparently wholesome,

and the Ewell spring appeared to be the purest water of the whole of the Farleigh group.

It must be remembered that the 8 feet of hop ground which covered the open-jointed pipes at Tutsham-in-Field was of a sticky, clayey nature, liable to crack and fissure in times of drought, and there can be little doubt but that the rain which washed this spot ran with its washings almost direct to the reservoirs. Under the circumstances which existed it is very important to study the rainfall and the exact times of its incidence. It is obvious that without rain no infective material could be washed into the 'spring,' and it is also obvious that a short sharp shower might do infinite mischief at Tutsham-in-Field and yet be insufficient to affect the level of the subsoil water in Maidstone. Let us look at the facts of the epidemic from this point of view.

The incubative period of enteric fever is stated by the Clinical Society of London to vary between five and twenty-three days. I am justified, therefore, in assuming that the majority of those who might receive a dose of poison to-day would be attacked between the seventh and twenty-first day following. Between June 28 and August 7 there had fallen only 0·21 inch of rain. At the end of a dry period the delay in the distribution of water would not be great, but it is obvious that a house cistern might be charged with infective material, and considerable delay might occur before the attacks, if the bulk of the household were away. After forty days of drought rain fell to the extent of 0·44 inch on August 7 and 8, and 0·13 inch fell on August 15. On August 17 and 18 there was a fall of 0·53 inch, and if this rain washed infective material to the reservoir it should cause attacks between August 24 and September 9. The first attack of the epidemic is stated to have occurred on

August 28, and between that and September 8 there were 101 attacks. On August 26 hop-picking commenced, and the population round the Tutsham spring was necessarily increased. On that day there fell 0·35 inch of rain, the heaviest fall in any one day since May 30. The effect of this shower should become manifest between September 2 and September 16. The attacks down to August 8 have been previously given, but between the 8th and 16th there were 385 attacks. On September 1 there was 0·31 inch of rain; again on September 5, in the very middle of the hop-picking, there fell 0·44 inch, the heaviest fall since March 2. The effect of this should become manifest between September 12 and 26. Omitting the cases down to and including the 16th, we find that between the 17th and 26th inclusive there were 625 attacks. There was 0·27 inch on September 8, hop-picking being still in progress. This would carry us on to September 27, 28, and 29, in which days there were 122 cases. On September 18 and 19 (hop-picking having come to an end on the 18th) there fell 0·51 inch. This would take us down to October 9, and we find that from September 30 to October 9 there were 237 attacks. On September 20 the Tutsham springs were cut off, the effect of which would not be fully manifest for three weeks. On October 12 the daily attacks suddenly dropped from eighteen to seven.

It must be borne in mind that the Tutsham spring had presumably sent a considerable dose of muddy water to the Barming reservoir on September 18 and 19, the very day before it was cut off, when there fell 0·51 inch of rain, and the influence of this would be ~~still~~ up to October 11 at least. On October 11 and 12 ~~both~~ daily attacks fell from eighteen to seven and never ~~rose~~ again above nine. We must remember that after

the Tutsham springs had been cut off there was the possibility of poison lurking in the foul Barming reservoir, the water pipes, and the house cisterns. On September 29 there fell 0·83 inch of rain, a shower of tropical severity, and it is exceedingly likely that in the stirring up of the town sewers there may have been some leakage into the water service. There is no evidence on the point, but such things do happen at such times. In any case the effect of the wholesale poisoning of part of the water system which had taken place would be likely to endure for some time. It was not till October 18 that the implicated water system was in great part (but not wholly) disinfected, and this process was not completed entirely until November 4. The full benefit of this would show itself three weeks later (November 25). In the weekly returns of attacks (see Table I.) there were only four for the week ending December 4, as against thirteen for the week ending November 27. Subsequent to November 27 there were only seventeen attacks.

The epidemiological facts of this outbreak are quite compatible with the theory that the dirty water supplied from Tutsham-in-Field was the main cause of the outbreak, and I do not think that the effects of the contamination could be expected finally to disappear until three weeks after the completion of the disinfection of the water service on November 4. The inspectors in their report fix October 18 as the day when the influence of the Farleigh water ceased to be felt in Maidstone, and they say (p. 82): "Nearly all the cases notified after October 18 (some 280 in number) are to be regarded as having had a cause other than the consumption of Farleigh water." This opinion seems to imply that in the estimation of the inspectors the dis-

infection of the Farleigh water system which began on October 16 and continued until November 4 was superfluous and useless.

Speaking of the 280 cases they continue: "By Mr. M. A. Adams they were referred to direct infection from previous cases and to insanitary conditions of water-closets, drains, and sewers. This explanation appears to us to be the probable one if the insanitary conditions referred to be taken in the wide sense of including the fouling of the soil by leakage from these defective drains and sewers. Recent researches into the life-history of the bacillus of typhoid fever go to show that this organism finds in a soil contaminated with foul matters from leaky sewers, drains, and cesspools conditions especially favourable to its vitality and multiplication. *That the soil on which Maidstone stands is thus contaminated was set beyond doubt by the evidence put before us.* To the existence of these conditions is mainly, we consider, to be attributed the remarkable persistence of fever in Maidstone after the primary cause of the outbreak had been removed by cutting off the Farleigh water-supply."

Do the facts of the case really establish the conclusion which the inspectors say is 'set beyond doubt'? I do not find a single word in the report or a single experiment to prove that the Bacillus typhosus was growing in the soil of Maidstone. The epidemic is remarkable not only for its severity but from the fact that six gentlemen, all eminent for their skill in bacteriology, failed to discover a single typhoid bacillus. The bacteriological investigations were upon a scale which was quite unprecedented and in so far as the Bacillus typhosus was concerned were entirely and absolutely negative. It may be, as the inspectors

hint was the case, that the *Bacillus typhosus* was permeating the soil of Maidstone in November, December, and January very much as a blue mould permeates a cheese, but no examination of the soil is recorded in the report. There are facts, however, which make strongly against any such contention. These were the total escape of the barracks and prison.

On page 26 of the report is the following paragraph : "The barracks and the Maidstone prison are both within the borough and both are connected with the town sewers. The population of the barracks was 300, this total including 166 men, 44 women, and 88 children. The water supplied to the barracks is that of the Boarley system of the water company's supply. No case of typhoid fever occurred in the barracks during the year. At the prison the average population throughout the year was 171, the total number of prisoners received being 1,925. The water used on weekdays is from a well 34 feet deep sunk in the Hythe beds of the lower greensand. On Sundays water is turned on to the prison from the Boarley mains. There have been no cases of typhoid fever or diarrhoea among the prisoners or staff during the whole of 1897." During the five months (August to December) there were probably 800 persons who drank water from the 34-feet well sunk in the 'contaminated' soil of Maidstone. A reference to the map (fig. 5) will show that the area of the prison is closely hemmed in on the north and east by fever-stricken houses, and the escape of the prison and barrack populations is most remarkable. Neither rise nor fall of subsoil water brought typhoid fever or diarrhoea to the prison.

The investigations connected with the Maidstone epidemic are of great interest as pointing to the wonderful

protection which the humus affords to the underlying water against pollution from above. The whole of the Farleigh springs were of the same character, the catch-pits of many of them were liable to invasion in time of flood, and the gathering-ground of most of them was highly cultivated and manured land. And yet none of them (always excepting Tutsham-in-Field) afforded

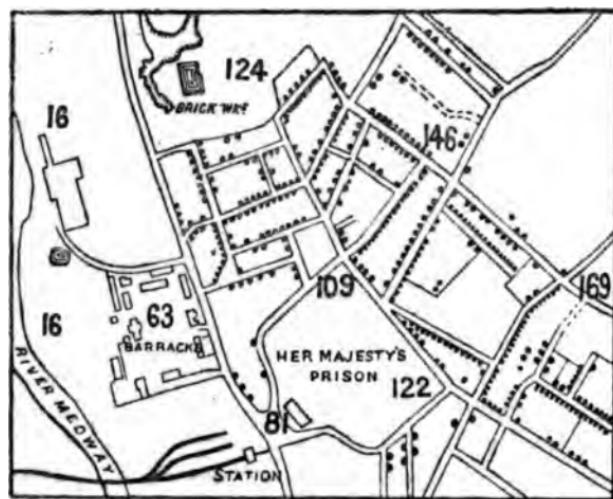


FIG. 5.

'Spot' plan of surroundings of Maidstone barracks and prison. The big numerals show the height above sea-level. The black dots are fever-stricken houses.

evidence of serious bacterial impurities. It may be added that in the third quarter of 1898 there was one death from enteric fever in Maidstone and another death from the same cause in the fourth quarter, so that the 'contaminated' soil of Maidstone was not able to contaminate the inhabitants during the drought of July, August, and September or the rains of October, November, and December of 1898.

CHAPTER VIII

IMMUNITY—DANGER OF WOUNDS

BACTERIOLOGISTS have abundantly proved that the germs of disease are ubiquitous. They are found in earth, air, water; in the dust and on the walls of our dwellings; in clothing, in meat, milk, bread, and even occasionally, as Andrewes has shown, in hot baked rice-pudding. With regard to most of the necessities of life we hear the cry of 'unclean,' 'unclean,' until the wonder is that we are any of us left alive to warn our neighbours. The fact that many of us manage to live to a respectable age and to die from something which is non-infective cannot but make us consider whether, after all, the immunity of the individual is not the fact which tends more than any other to the improvement of the public health. It is wholesome for us to remember that the greatest sanitary achievement of our time has been the practical disappearance of typhus fever. Of the *causa causans* of this disease we know nothing. Its absolute disappearance has not been produced by successful germ hunting. Its disappearance is probably due to the improved conditions under which the masses of the population live as regards food and cleanliness. Few of us doubt that if this country should become involved in war, and food should become dear and scarce in consequence, the relative immunity of the population would

IMMUNITY

be lessened and typhus fever would re-assert its sway. Whether we succumb to an infective disease or not probably depends in great measure upon the dose of the poison which we receive. When an endemic disease such as enteric fever becomes epidemic it is due to the sudden dissemination of a poison in relatively large or virulent doses. Even in the most severe epidemics it is rare for more than 10 per cent. of those who have run obvious risks of receiving the poison to be attacked. The questions of virulence and vulnerability are most important. It seems to be well established that the virulence of some of the pathogenic microbes varies immensely with the conditions of soil, temperature, air, sunlight, &c., under which they are grown, and it is a fact that must be remembered that it is not always the pure cultivation which manifests most virulence. Many infective diseases assume a virulence in the tropics which is rarely met with in temperate countries. This appears to be true of tropical malaria, enteric fever, cholera, yellow fever, anthrax, and tetanus. In hot countries where a temperature equal to the optimum for the growth of many pathogenic microbes is often continuously maintained for weeks in succession, the risks of contagion and the danger of uncleanliness must often have become apparent in a manner more convincing than is the case among us. The repeated injunctions as to uncleanliness in the Mosaic law, and the rigid rules laid down as to the conditions which made a man unclean and which necessitated his subsequent purification, must have been the outcome of experience. To eat with unwashed hands in a tropical country and without knives and forks would clearly be to run considerable risks. The regulations in force among the Hindus were even more stringent, and although some of the regula-

tions may appear to us to be extravagant and nonsensical, it is impossible not to admit that most of them have for their aim the protection of the individual and his fellow man from the risks of infection.¹

' In the Abbé Dubois's book on Hindu Manners, Customs, and Ceremonies, translated by Beauchamp (Clarendon Press, 1897), will be found a chapter (vol. i. p. 238), largely culled from the great book of Brahmin ritual called *Nittia-Karma*, on hygienic rules, and among them a section on 'Rules to be observed by Brahmins when answering the Calls of Nature.' 1. Taking in his hand a big *chembu* (brass vessel) he will proceed to the place set apart for this purpose, which should be at least a bowshot from his domicile. 2. Arrived at the place he will begin by taking off his slippers, which he deposits some distance away, and will then choose a clean spot on level ground. 3. The places to be avoided for such a purpose are the enclosure of a temple, the edge of a river, pond, or well, a public thoroughfare or a place frequented by the public, a light-coloured soil, a ploughed field, and any spot close to a banyan or any other sacred tree. 4. A Brahmin must not at the time wear a new or newly-washed cloth. 5. He will take care to hang his triple cord over his left ear and to cover his head with his loincloth. 6. He will stoop down as low as possible. It would be a great offence to relieve oneself standing upright or only half stooping; it would be a still greater offence to do so sitting upon the branch of a tree or upon a wall. 7. While in this posture he should take care to avoid the great offence of looking at the sun or the moon, the stars, fire, a Brahmin, a temple, an image, or one of the sacred trees. 8. He will keep perfect silence. 9. He must chew nothing, having nothing in his mouth, and hold nothing on his head. 10. He must do what he has to do as quickly as possible, and rise immediately. 11. After rising he will commit a great offence if he looks behind his heels. 12. If he neglects none of these precautions his act will be a virtuous one, and not without merit; but if he neglects any of them the offence will not go without punishment. 13. He will wash his feet and hands on the very spot with the water contained in the *chembu* which he brought. Then taking the vessel in his right hand and holding his private parts in his left, he will go to the stream to purify himself from the great defilement which he has contracted. 14. Arrived at the edge of the river or pond where he purposes to wash himself he will first choose a suitable spot and will then provide himself with some earth to be used along with the water in cleansing himself. 15. He must be careful to provide himself with the proper kind of earth and must remember that there are several kinds

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There can be no doubt that the health and vigour of the individual are all-important in relation to infective disease. The enervating influence of a tropical climate upon Europeans is recognised as a potent predisposing cause of infective disease, and if to the effects of climate be added those of inordinate fatigue and insufficient

which cannot be used without committing an offence under these circumstances. Such are the earth of white ant nests, potter's earth, road dust, bleaching earth, earth taken from under trees, from temple enclosures, from cemeteries, from cattle pastures, earth that is almost white like ashes, earth thrown up from rat-holes, and such like. 16. Provided with the proper kind of earth he will approach the water, but will not go into it. He will take some in his *chembu*. He will then go a little distance away and wash his feet and hands again. If he has not a brass vessel he will dig a little hole in the ground with his hands near the river side and will fill it with water which he will use in the same way, taking great care that this water shall not leak back into the river. 17. Taking a handful of earth in his left hand he will pour water upon it and rub it well on the dirty part of his body. He will repeat the operation, using only half the amount of earth, and so on three times more, the amount of earth being lessened each time. 18. After cleansing himself he will wash each of his hands five times with earth and water, beginning with the left hand. 19. He will wash his private parts once with water and potter's earth mixed. 20. The same performance for his two feet, repeated five times for each foot, beginning, under the penalty of eternal damnation, with the right foot. 21. Having thus scoured the different parts of his body with earth and water he will wash them a second time in water only. 22. After that he will wash his face and rinse his mouth out eight times. When he is doing this last act he must take very great care to spit out the water on his left side, for if by carelessness or otherwise he unfortunately spits it out on the other side he will assuredly go to hell. 23. He will think three times on Vishnu and will swallow a little water three times in doing so.

In the course of some remarks on *Ankylostoma duodenale* in dogs, Mr. Arthur Powell (late of Kalain, Cachar, and now of Bombay) (*Brit. Med. Journ.* vol. i. 1900, p. 1,452) says : "It is a fact, not generally known outside India, that a Hindu considers it a grave insult to address anyone without washing the mouth after defaecation. Anyone who has travelled on the rivers of Assam is familiar with the sight of the banks in the early morning. Every riparian native defaecates at the water's edge, completes the 'toilet of the perineum' in the river, and then

food, the risks of infection getting a hold of the organism are greatly increased. Director-General Jameson told us in the debate on enteric fever already alluded to that "in almost all the posts occupied by European troops co-operating with the various columns in Afghanistan, extending from the British territory up to Kabul and Kandahar, cases of enteric fever appeared, some of which posts were occupied probably for the first time since the world began." In the Nile expedition in 1889 those troops suffered most which had undergone most exposure and fatigue, "and it becomes difficult to resist evidence tending to show that in the causation of this disease there may be more factors than are generally acknowledged." Dr. Maclean, R.N. (in a letter to Sir J. Fayerer), alludes to the occurrence of enteric fever in the Island of Ascension, under circumstances of close observation where no connection could be traced with defective sanitary arrangements, though it is probable that malarial influences did occur. "There is no such thing as a drain or a cesspool in the island, all the sewage and other filth being removed daily and thrown into the sea to leeward of all dwelling-houses. The water, partly collected from the roofs of buildings

rinses out his mouth from the same water, though he sees the whole bank studded with his fellows engaged in one or other stage of this operation."

Mr. Charles Bentley, M.B., C.M. (*Brit. Med. Journ.* January 25, 1902, p. 190), contends that 'ground itch,' a skin disease of the feet affecting coolies working in the tea gardens of Assam during the wet season, is caused by the larvae of the *Ankylostoma duodenale*, which are hatched out from the faeces deposited at random by the coolies near their 'lines.' Mr. Bentley's experiments appear to bear out his contention. The larvae are killed by desiccation, so that they disappear in the dry season. [The deposition of faeces at random is indefensible. They should be deposited methodically on a well-tilled humus, which should be planted forthwith.—G.V.P.]

during rain and partly condensed, is stored in iron and cemented stone tanks and removed from all possible sources of contamination." It is of course possible that in a case such as this the *Bacillus typhosus* may be lying dormant in the body ready to assert itself when bodily enfeeblement reaches a certain pitch. It has been asserted (and the assertion received the support of the late Professor Kanthack) that the *Bacillus typhosus* may be found in an abscess years after the attack, and the same thing holds good in a less degree with regard to the microbes of diphtheria and cholera.

Nothing is better established with regard to tubercle than its relation to overcrowding and unwholesome occupations. Three times as much tuberculous disease occurs in the centre of London as at the outskirts, and an hotel servant in London runs a risk of dying from tubercle nearly ten times as great as that of the farm labourer. In our combat with this disease we must by no means confine our efforts to microbe hunting. So again with 'filth diseases,' we must remember that almost all infective diseases are especially fatal to those who live in the midst of filthy surroundings. It is not, I think, at all necessary to assume, although it is possibly the case, that specific organisms are growing in the filth. In the cramped dwelling of the artisan, where the privy is often barely six feet from the back door, the risks of faecal befoulement of the food or person are very great, and when in such places large pails of faeces are left to putrefy for a week or more, it is not to be wondered at that the inhabitants should show an undue predisposition to the infection of enteric fever, as has been pointed out by Boobbyer and others. But it must be remembered that wherever putrefaction is going on and wherever anaerobic organisms are grow-

ing in a filth-sodden soil unwholesome gases, such as CO₂, H₂S, CH₄, and H, are being given off, and it is impossible not to admit that the breathing of these gases from week end to week end in the crowded courts of a great city may so lower the vitality of the body as to increase its vulnerability to infection of all kinds. But these gases which are naturally given off from sewers and sewer traps, from cesspools, from privies and from waterlogged and filth-sodden soil are accompanied by 'odours' which are often too subtle for the chemist to analyse but which, nevertheless, are sufficiently potent to make a strong man sick and faint and to reassert themselves in the excreta twenty-four hours after being inhaled. The odour given off by a tropical arum at Kew some few years since during the time it was in flower and just ripe for fertilisation was of a kind which could only be described as appalling and which made it impossible to enter the house where it was growing without putting a clip on the nose and holding the breath. I merely want to emphasise the fact that odours may have a power which neither the chemist nor the bacteriologist can gauge, and that we must be ready to admit that to live in stinks and filth must depress the health and increase the susceptibility to infection by microbes some of which have perhaps a greater measure of ubiquity than we are definitely aware of.

Professor Stewart Stockman¹ reports an investigation which he carried out on a septic organism which proved fatal to 380 fowls out of 400 on a poultry farm. He says: "The most important thing about this bacillus seems to me to be its fatal effect on tuberculous birds while it appears to be non-pathogenic, or nearly so,

¹ *Veterinarian*, September, 1898.

It is also interesting to note that cattle which have been infected with the coccidium oviforme do not seem to be much affected by it. This, again, affords fresh evidence in favour of the theory about certain other microbes—namely, that they are only pathogenic to the enfeebled animal.

It is an established fact and is now universally accepted that infective organisms may gain access to the body through the smallest conceivable wound whether of the skin or the mucous membrane. The various forms of septicæmia as well as erysipelas and malignant œdema are due to this cause. Tetanus, as we have seen, is always due to the inoculation of a wound, and it is a question whether anthrax of cattle is not more often caused by inoculation of a skin abrasion than hitherto has been suspected. Whether any of our common infective fevers are communicable by accidental inoculation is a moot point and one which is certain to receive a full share of attention in the immediate future. It is certain that in the transmission of plague a broken skin bears a most important part, and it may be that other infections may be conveyed in the same way. A distinguished pathologist is credited with having infected himself with enteric fever by a post-mortem wound. The infections brought about by flies, ticks, and mænagnithæ are at present attracting much attention from pathologists, and it seems probable that the danger of certain 'soils' and climates may be shown to be due in an increasing degree to the insects which find in the localities the various conditions necessary for their existence. It may be that in some instances an abrasion of the skin made by an insect may merely serve as a point of entrance for infective organisms abounding

in the surface of the soil or in the immediate surroundings of the individual and having no necessary connection with the insect itself. It seems certain, however, that in the majority of instances which have been worked out a particular species of insect serves as an intermediary host for a specific organism which affects a specific animal. We hear a good deal in a loose and speculative way about flies conveying fever. This may be true, but we must always bear in mind what I feel inclined to call the excessive specialism of nature. Insects which feed on dung and carrion are seldom attracted by the food of human beings, and I confess to being somewhat sceptical as to the accidental conveyance of infection by 'flies' which heedlessly buzz first into the faeces and then into the milk. The pathologist of the future will clearly have to call in the help of the entomologist.

CHAPTER IX

PRACTICAL CONSIDERATIONS

THE Maidstone epidemic has been very useful in directing attention to some of the common conditions which endanger water-supplies. Pasteur and all subsequent bacteriologists have directed attention to the value of the earth as a filter, and it is a matter of common knowledge that a very shallow layer of compact earth will remove the bacteria and much of the organic matter from water percolating through it.

The greatest danger to shallow wells is to be found in subterranean collections of filthy fluids which leak through fissures in the earth, and with a gradually increasing hydraulic pressure. If there be no such dangers in the immediate neighbourhood, then a properly constructed shallow well is safe. The lined well five feet deep which I have in the middle of my garden has given water of exceptional purity for years, notwithstanding that the ground is cultivated with human excreta to within six or seven feet of the well. Dr. Macmartin Cameron, medical officer of health for Kirkcudbright and Wigton,¹ shares my opinion that a 'surface well' properly constructed and in a selected situation is a safe source for water. Dr. Cameron's paper embodies much experience obtained in his official

¹ *Brit. Med. Jour.* August 18, 1898.

capacity, and many of his observations are worthy of quotation as showing some of the limits of danger and safety in relation to shallow wells.

“*The construction of new village wells.*—When the wells of a village are shown to be contaminated, and a new water supply becomes imperative, it is not, as a rule, necessary—not, at least, in the province of Galloway, for which I have the honour to be medical officer of health—to press on a gravitation scheme as the only way of meeting the difficulty. A simple and inexpensive well scheme will often suffice. All that is requisite is to sink new wells outside the precincts of the village on higher ground if practicable. Commonly enough, the selfsame water that feeds the old wells may be tapped at a point before it has entered the polluted ground of the village. All that is then required to secure perpetual immunity from pollution is to obtain possession of a sufficiency of ground around each well to be devoted for all time to purposes of filtration. With a sufficient reserve (anything, say, from half to one acre, according to circumstances) little or no danger will accrue from ordinary agricultural operations beyond, but it would be better that as much as possible of the outlying ground should be left under grass. There is no safer or better water than that which a surface well in an old grass park can be got to yield. This is an ideal site. I should have no fear even of a top dressing of manure, provided the ground in the immediate vicinity of the well were not profaned.

“Professor Hunter Stewart (Edinburgh) remarked that Dr. Vivian Poore’s experiment with a six-feet well carefully cemented at the sides gave water which contained seven micro-organisms to the cubic centi-

metre and the *Bacillus coli* was conspicuous by its absence. A part of the supply of the city (Edinburgh) was from wells near the Pentland Hills, not more than eight feet deep, situated in highly manured land, and exposed to pollution from neighbouring middens. From the water of these particular wells of a maximum of eight feet in depth, he found a maximum of micro-organisms of eleven to the cubic centimetre, and a minimum in three out of eight wells of absolute sterility. These observations abundantly supported the observations of Dr. Poore."¹

Reverting to the conditions which obtained at Maidstone, I will mention a few considerations which, though obvious enough, are often neglected. During a drought, such as occurred in June, July, and August, not only would the stiff hop land be liable to crack, but the earthworms would retire to the lowest point in search of moisture. At such times they go deeper and deeper into the soil, and lie coiled up in oval knots at the bottom of their burrows. I have upon the table a piece of a worm-burrow removed from my garden in September last at a depth of more than two feet. It is more than a quarter of an inch in diameter, and would act as a drain from the surface to the deeper parts. This question of worm-burrows is one of great practical importance to sanitarians, because, especially after a drought, they may serve to conduct surface water to considerable depths without its really being influenced by that biological filter, the humus. Darwin² says that although worms generally live near the surface they may burrow to a considerable depth during long-continued dry weather and severe cold; the depth varies with the soil.

¹ See p. 126. ² *Vegetable Mould and Earthworms*, p. 111 *et seq.*

"In a bed of fine sand overlying the chalk which had never been disturbed, a worm was cut into two at fifty-five inches, and another was found here at Down in December at the bottom of its burrow at sixty-one inches beneath the surface. Lastly, in earth which had not been disturbed for many centuries a worm was met with at a depth of sixty-six inches, and this was in the middle of August. The burrows are lined with viscid earth, voided by the worm, which gives at once smoothness and a certain amount of durability to the burrow."

Then, again, we must not forget the effect of harvest on the soil. Before harvest the amount of moisture retained upon the growing plant and absorbed by the still active root would prevent anything except the heaviest rain from penetrating, although even at such a time one must admit that even half a pint of water, if thrown on a suitable place, might travel *via* clay-crack and worm-burrow to a depth of five feet or more. When harvest begins not only is the earth deprived of its green protecting mantle, but the upward drainage of the root action ceases, and with the falling temperature of autumn and the lessened evaporation the rain which falls has an ever-increasing power of penetrating the soil. In a hop garden the first step in harvesting is the removal of the pole, and the hole thus left is capable of conducting rain water to a depth in the soil of two feet or more. If, therefore, there be open-jointed stoneware pipes in a hop garden at a depth of two or three feet from the surface, it is possible, nay, likely, that when the hop-poles are removed a surface channel three or four inches in diameter may communicate with these pipes and a

heavy rain may wash solid matters into them from the surface.

There are other practical matters which need consideration in relation to liability of springs to suffer from surface contaminations. If a plant or tree dies—be it hop, beech, hazel, or what not—the roots, instead of helping the upward drainage of the soil, and preventing surface water from reaching the springs, may serve as a direct guiding channel from the surface to the spring. And if the spring be artificially maintained by under-draining it with open-jointed pipes (an operation which involves a considerable disturbance of the ground and its artificial re-making), this danger is considerably increased. Burrowing animals are necessarily a danger in this connection, and if rats or rabbits establish themselves anywhere near the outcrop of a spring, they must be exterminated. Rats and rabbits sometimes burrow very deeply, but I have not been able to get any authentic statement as to the maximum depth in the soil to which they may penetrate. Rats are animals which the sanitarian is bound to regard with some suspicion. In relation to the plague they seem to be a very definite danger, and when they crawl from the sewers (their favourite lurking place in towns) to our houses it is possible that they may be at least as dangerous as sewer gas. Rats occasionally make their homes in dung-heaps, especially if such heaps be made in outlying places and are long neglected. It is well known that they invade cornricks, in spite of elaborate precautions, but it is safe to regard the rat as a haunter of foul places and a lover of filth, and its presence among us is often due to our permitting accumulations of filth, and our delay in putting filth to its proper use.

Although it is probable that a very few inches of soil may, if properly tilled and cultivated, serve as an efficient protection to the subsoil water, we must nevertheless be mindful of the accidents which may serve to conduct filth from the surface to the springs. The danger of having a catch-pit flooded from the surface is one which can easily be guarded against by covering with suitable structures. The ground above the outcrop of a spring ought to be carefully turfed to a point which is six or seven feet above the level of the spring. A spring used as a water-supply must be very carefully watched. If the water become turbid or if a worm find an entrance to the catch-pit the use of such water should be discontinued, or it must be boiled and filtered until the cause of the turbidity be satisfactorily demonstrated. Such springs should always be carefully inspected during heavy rains, because it is at such times especially that shallow springs establish surface relations.

The question arises whether it is safe to allow the gathering ground of a spring to be cultivated. This is a national question of the very greatest importance. No nation which is dependent upon its native soil for food production could possibly afford to raise such a question. What would a Chinese say if you told him that the water of his well contained a trace of ammonia and had a permanent hardness above the local standard, and therefore his tea-gardens and rice-fields must remain unmanured and be converted to permanent pastures? His answer to the 'foreign devil' who ventured to propound such a theory had better go unrecorded. But in China they boil the water before drinking it and they do not seek to fix the responsibility for the absolute purity of the water of a district upon a single underpaid

individual; nor do they talk about 'manslaughter' when a break-down in the arrangements from some cause, natural or artificial, brings about an outbreak of disease.

Provided there be a fairly thick layer of earth above the spring I am inclined to think that there is safety rather than danger in the cultivation of the overlying soil. Any spring which is covered by seven feet of soil—that is, six inches more than the depth of the deepest recorded earthworm—might be considered safe from the risk of unchanged organic matter soaking into it from above.¹ In the first place, the cultivation of the land ensures that it is visited more or less frequently by individuals more or less intelligent. A gathering ground for water which is remote from the haunts of man has dangers of its own. Rats or rabbits may burrow in it and these as well as other animals and birds may provokingly die in the runnels which primarily collect the rain-water, and I cannot understand how anybody who has ever walked over a moor can maintain the thesis that water running off a neglected waste is safer to drink than that which has percolated through well-cultivated land.

Last year I visited a spring which was being used for public purposes and which was and had been supplying water of excellent quality. The spring, which rose in a little copse lying in a natural dell in a remote and seldom visited spot, was enclosed and protected against surface washings which the configuration of the ground would certainly conduct towards it in times of flood. Some of the trees were dead and their stumps

¹ For the same reason, although I agree with Dr. M. Cameron, I am of opinion that the first eight feet of all 'shallow' wells should have an impermeable lining.

and roots were permeated with fungi and were rotten, and one could not but regard it as possible that these rotten roots might serve as conducting channels from the surface to the water which was running beneath to the neighbouring town. Possibly the workings of rabbits or other burrowing beasts had hastened the death of some of the trees. If so, the burrows might run very close above the gathering water. Further, there was evidence to show that this dell was visited by an occasional tramp and had been made a playground by the children from the nearest group of cottages. It is clear that the non-cultivation of this particular spot was a source of danger rather than of safety to the purity of the spring.

Enteric fever is a disease especially liable to become epidemic in the autumn. The autumn is the time of year when after removal of the crops the parched earth is soaked, and it is also the time of year when there are large accumulations of manurial matters waiting to be spread upon the land. In the summer the yield of springs is seldom increased no matter how heavy may be the rains. The water which falls upon the earth is all absorbed by the roots of growing plants and to a large extent mounts upwards in the plant to help metabolism and to quicken growth. With the ripening and harvesting of the crops root action ceases, water which falls upon the earth tends more and more to percolate, and when the early frosts have given their death-blow to the greenery of summer then the springs begin to rise and to yield more water. The nitrification and final solution of organic matter in the soil goes forward mainly, if not entirely, in the upper layer, and it is doubtful if any appreciable amount of oxidation takes place in the parts which are beyond the reach of

tillage. A certain proportion of the mineralised organic matter necessarily escapes absorption and percolates with the water, and if there be much unused nitrates remaining in the soil after harvest the amount which percolates to the springs may be considerable. If nitrates be placed upon the soil in the form of artificial manures they are often dissolved and washed beyond the reach of plant roots with the first heavy shower. Not only nitrates but soluble salts of ammonia are placed on the ground in large quantities, and the presence of free ammonia in the drainage water of cultivated land which has been *artificially* manured need not be an indication of pollution in the proper sense. It must be very hazardous to draw just conclusions as to the wholesomeness or otherwise of water from the amount of nitrates in it.

CHAPTER X
AGRICULTURE

THE facts with which we have been dealing in these lectures show:—1. That there are certain organisms which are indigenous to the soil and ubiquitous. These organisms, if they contaminate a surgical wound or are inoculated, may cause septicæmia, erysipelas, malignant œdema, or tetanus. They are very possibly necessary saprophytes, and we recognise that it is useless to attempt to 'stamp out' the germs of these surgical contagia, although (thanks to Lord Lister) the surgeon is able to protect his patient from the evils which arise from them and to prevent their cultivation in hospitals. Apart from accidental inoculation these organisms are not dangerous. We must often swallow them with our food and drink and inhale them with our breath and no practical harm results. These contagia are persistent in the soil and are probably most common in soils which are richest in organic matter. 2. The contagium of anthrax is apparently difficult to eradicate from a soil which has once been contaminated with it. This is probably due to the fact of sporulation and to the spore being very resistant to external influences of all kinds. The evidence, such as it is, points to the fact that in temperate countries at least the contagium dies out of the soil in time. M. Pasteur's experiments were vitiated by the circum-

stance that they were made in districts where the disease was and had been rife. More information is needed as to how far the infection of animals depends upon wounds of the skin or mucous membrane and on the vulnerability of the animals by the mal-hygienic conditions in which they live. It is possible that in tropical countries the *Bacillus anthracis* is indigenous to the soil. Man apparently does not acquire anthrax by inhaling or swallowing pulverised earth. He is always infected through the medium of infected animals or their skins, flesh, or wool. 8. To what extent malaria is directly a soil disease, apart from the mosquito as a connecting link, is in the present state of our knowledge doubtful. There is no doubt, however, that malaria disappears before drainage and cultivation. 4. With regard to enteric fever, diarrhoea, plague, and some other diseases there can be no doubt that they are all favoured by filth, although we are ignorant of the precise way in which filth favours the occurrence of these diseases. Some might say that a filth disease is a soil disease and that there is no line of demarcation between the two. This is true, but it is nevertheless very necessary for practical purposes to distinguish the one from the other. We are all agreed that it is dangerous to allow the purlieus of a house to become sodden with liquid filth, but it might be equally dangerous to the public health to encourage the idea that it is dangerous to dung the land for fear of inoculating it with infectious disease. Happily from the laboratories we get comfort in this matter. Sidney Martin has shown (as Dempster had previously shown with regard to peat) that 'virgin soil,' whether sandy or peaty, is, even when sterilised, fatal to the *Bacillus typhosus*, and one naturally asks, What is virginity? and whether cultivated soils by

excessive production do not tend, paradoxical as the question may sound, to return to that condition of virginity in which they are able to grapple with infective organisms? The evidence goes to show that cultivation and production are the enemies of dung infections. Robertson and Gibson found that a growth of grass was fatal to the *Bacillus typhosus*. That dung contagia must be destroyed or their virulence be diminished by tillage is self-evident. Were it otherwise our race must long since have been extinguished. The race which has shown the greatest persistence in this world (the Chinese) is precisely that one which has systematically inoculated its native soil with dung contagia for three or four millennia. Politically they are said to be sick, but physically and economically they are 'going strong' and are likely to continue. 5. The fact that most of the alleged soil diseases are more rife in the crowded centres of population than in the rural districts is a fact which must not be lost sight of. Whether this be due to the greater vulnerability of town populations or to the soakage of the purlieus of the house from leaking sewers it is difficult to say. In any case it is incontestable that soil diseases (so-called) are most rife precisely in those spots where the ground is not cultivated.

Infective organisms contained in dung have to run the gauntlet of many enemies, such as dogs, sparrows, rats, flies, maggots, beetles, earthworms, moles, sunlight, fresh air, innumerable saprophytes (both aerobic and anaerobic), and the chemical action of the roots of plants. Of course, there may be spores which emerge from these ordeals unharmed and still virulent, but it is evident that, being mortal as we are, they are likely to succumb before the digestive and disintegrating processes which they encounter. The bulk of the evidence goes

to show that contagia must be largely destroyed in the soil and that agriculture is really the corner-stone of preventive medicine. It becomes of great importance, therefore, to devise means by which the fertilising material of our towns may be applied to the soil with safety and despatch.

I may be pardoned for reverting to the method of dealing with human excreta which I have practised now for twelve years in my experimental garden at Andover : (1) the excreta are moved every day so that there is no accumulation of filth near the dwelling ; (2) they are put just below the surface of freshly-dug ground so that they are out of the reach of flies ; and (3) the ground is planted with plants of the cabbage order as quickly as may be, so that very soon there is no possibility of dust being blown off the surface of the ground, and the mass of living cabbage leaves freshens the air. I cannot believe that dust from agricultural land is a danger in this country, whatever it may be in the tropics. In my garden the ground treated in the manner stated, apart from the growth of cabbages, soon becomes coated with a green growth of algae. Mr. A. Gepp, of the Natural History Museum, who visited my garden in 1898, took some of this growth away and very kindly examined it and he pronounced it to consist of algae—"chiefly Vaucheria sessilis (in good fruiting state) with a little ulothrix, a gloeocystis, and an oscillatoria." Such a growth effectually prevents the possibility of dust.

Dr. Samuel Hyde,¹ speaking on the open-air treatment of consumption, says: "Sparseness of vegetation, like thinness of population, is a climatic factor favourable to the treatment of consumption. Where vegetable life abounds there vegetable decomposition

¹ *Brit. Med. Jour.* October 8, 1898.

must also abound and *vice versa*. Wherever there is life we have a corresponding amount of death accompanied necessarily by the products of decomposition." This is quite true and our experience teaches us that, provided the supply of food be adequate, a high level of health may be maintained in places where there is little or no vegetation, as upon the sea and on alpine heights and in arctic solitudes. "Wherever there is life," says Dr. Hyde, "we have a corresponding amount of death." That is true, but the converse is also true, and we may say that wherever there is death we have the potentiality of a corresponding amount of life. I believe that what I have called the circulation of organic matter is a beneficent fact from which there is no escape, and that whether we derive good or ill from the inevitable processes of death and decay depends very much upon ourselves. We must never forget that vegetation purifies the soil, freshens the air, rests the eye, and prevents dust, and these facts must be recognised as to a great extent counterbalancing the evils of dead leaves.

There are always *pros* and *cons* which have to be weighed. Nothing makes entirely for good or entirely for evil and we have always to balance our accounts and to see whether the general effect be good or ill. The British sanitarian is so circumstanced that he need not trouble himself at all about the most important of all sanitary considerations—viz. food-supply. He is busy in burning or washing into the sea every kind of fertilising matter, and if a general coal strike or a war were suddenly to bring famine with its attendant diseases to our doors he would protest that that was no concern of his. With our steadily diminishing birth-rate and the daily increase of institutions for the reception of those whose moral, mental, or physical diseases

prevent them from earning their own living, it is difficult to believe that the stamina of our highly civilised urban populations is increasing. Apart from the question of food-supply, it is, I believe, absolutely necessary to encourage agriculture in order that our race may be maintained in vigour. The strong contrast which exists between the agriculturist and the town worker in the matter of health is well known.

Table (deduced from Table IV. of the Supplement to the Fifty-fifth Report of the Registrar-General) showing the mortality from certain specified causes in each of three sections of occupied males, as compared with that among all occupied males, the mortality of the latter being taken as 100 in each case.

	All Occupied Males	Occupied Males, London	Occupied Males, Industrial Districts	Occupied Males, Agricultural Districts
All causes	100	120	131	72
Influenza	100	100	100	100
Alcoholism	100	188	146	54
Rheumatic fever	100	100	114	86
Gout	100	800	100	100
Cancer	100	184	109	91
Phthisis	100	150	121	78
Diabetes	100	114	100	100
Diseases of the nervous system	100	107	182	77
Diseases of the circulatory system	100	107	122	75
Diseases of the respiratory system	100	124	166	51
Diseases of the liver	100	111	119	89
Other diseases of the digestive system	100	100	129	82
Diseases of the urinary system	100	137	122	78
Accident	100	86	105	79
Suicide	100	129	114	86
Other causes	100	91	180	76

Dr. Tatham's letter to the Registrar-General on the mortality of males engaged in certain occupations in

the three years 1890-92, which constitutes Part II. of the Supplement to the Fifty-fifth Annual Report to the Registrar-General, shows clearly enough that the agricultural classes in this country enjoy a large measure of health. Dr. Tatham's statistics refer to occupied males between the ages of twenty-five and sixty-five years, and the tendency to disease and death is indicated by a mortality figure, the mortality for all males between twenty-five and sixty-five years of age being taken as 100. The preceding table (p. 92) taken from p. 18 of this report shows the mortality of three great classes of the community with perfect clearness.

	All Occupied Males	Occupied Males in Agricultural Districts	Agricultural Class	Agriculturists in Agricultural Districts	Farmer, Grazier, &c.	Farmer, Grazier, &c., in Agricultural Districts	Farm Labourer	Labourer in Agricultural Districts	Gardener, Nurseryman
All causes . . .	100	72	63	64	59	53	66	70	58
Influenza . . .	100	100	109	112	115	112	112	118	82
Alcoholism . . .	100	54	31	31	46	31	31	31	31
Rheumatic fever . .	100	86	86	71	86	71	71	57	100
Gout . . .	100	100	50	50	50	100	50	50	50
Cancer . . .	100	91	82	84	82	77	82	86	82
Phthisis . . .	100	73	57	63	43	44	62	70	61
Diabetes . . .	100	100	86	86	143	157	71	71	57
Diseases of nervous system . . .	100	77	62	63	62	50	65	71	57
Diseases of circulatory system . . .	100	75	66	68	61	52	71	75	61
Diseases of respiratory system . . .	100	51	52	49	41	29	58	57	48
Diseases of the liver . . .	100	89	63	59	96	81	48	56	63
Other diseases of digestive system . . .	100	82	82	75	96	75	79	75	64
Diseases of urinary system . . .	100	78	59	59	71	68	51	56	63
Accident . . .	100	79	63	68	53	54	74	77	39
Suicide . . .	100	86	71	71	100	129	57	50	71
All other causes . . .	100	76	73	76	65	61	79	86	61

The preceding table (p. 93) which is deduced from Table IV. shows the mortality from certain specified causes in the agricultural class as a whole and in its several divisions as compared with the standard mortality among all occupied males, the latter being taken as 100.

Out of the sixteen causes specified in this table, there is only one in which the mortality of agriculturists as a class exceeds that of occupied males generally. The exception is influenza, the mortality from which disease shows an excess equal to 9 per cent. The chief excess under this heading probably occurred in the first quarter of the year 1892, which was marked by a severe outbreak of influenza specially affecting the country districts. The mortality among agriculturists from phthisis does not exceed 57 per cent., and that from diseases of the respiratory system does not exceed 52 per cent. of the standard mortality among occupied males, and their mortality from all other diseases of the local class is considerably below the same standard.

These tables show conclusively that agriculturists are among the healthiest class in the community and that even the farm labourer in the matter of health is 88 per cent. better than the average. This is a matter of great interest and importance. He is often represented as half-starved, miserably housed, a martyr to rheumatism and poisoned by filthy water. As a matter of fact as regards sobriety and health he might be taken as a model by the rest of the industrial classes. There is another point of view from which agriculture is of great importance. We are beginning to find out that a factory hand who has to keep pace with steam machinery becomes 'too old for his work' at a comparatively early age. Defects of eyesight or hearing or a lessening

of acuteness and nimbleness soon unfit a man for employments where dexterity is of more importance than experience. There has been much talk of late of 'old-age pensions,' but it must be admitted that even if the financial difficulties of the question could be overcome the prospect of being *without employment* and existing on a pittance without any true interest in life after the age of fifty-five years is not cheerful. I believe that the practice of agriculture is the only remedy for this, and that the best old-age pension will be found in the possession of an acre or so of land. Not only are the ordinary horticultural operations all possible for a man long after he is capable of attending to machinery, but such a possession would give him an interest in life and he would find that the productiveness of his land would certainly increase with time and in direct proportion to the amount of skill and labour expended in tillage and cultivation and the quantity of organic manure placed upon the soil.

The greatest need of our country at the present day I believe to be an increase in the facilities for the transfer of land. Many of the above facts appear to show that the practice of agriculture is absolutely essential, apart from the question of food, for the maintenance of the vigour of our race. Anything which discourages or increases the difficulties of agriculturists can hardly be in the interests of the public health.

CHAPTER XI

THE MAINTENANCE OF THE FERTILITY OF THE SOIL

THERE is much evidence to show that dung is absolutely necessary to maintain the fertility of the soil. In a paper by Sir John Lawes and Sir Henry Gilbert on the valuation of unexhausted manures¹ the difference between organic manures and mineral manures is well brought out. The lasting effects produced by farmyard manure (14 tons to the acre) are shown in the annexed table:

TABLE I.—*Experiments with Farmyard Manure on Permanent Grass Land.*

—	Unmanured every Year	Manured 1856–63, Unmanured since	Excess of Manured over Unmanured
8 years 1856–63 } 1st crops {	Owt. $23\frac{3}{4}$	Owt. $42\frac{1}{2}$	Cwt. $19\frac{1}{2}$
12 years 1864–75 } only {	$19\frac{1}{2}$	$32\frac{1}{2}$	$13\frac{1}{2}$
20 years 1876–95 (1st and 2nd crops)	$25\frac{1}{2}$	$29\frac{1}{2}$	4

In only one year—1893, a year of drought—did the manured plot give less produce than the unmanured. The authors say: ‘It is true that the application of 14 tons of farmyard manure per acre per annum for eight years in succession is an unusually heavy dress-

¹ *Journal of the Royal Agricultural Society*, vol. viii. 1897, p. 674.

ing; but it is of interest to know that the residue was very materially effective for some years, and that it was more or less so for THIRTY-TWO YEARS after the application" (the capital letters are my own). The following table giving experiments with barley tells the same tale.

TABLE II.—*Experiments with Barley, 1852–96.*

—	Un-manured every Year	Mixed Minerals every Year (no nitro- gen)	Farmyard Manure	
			Every Year	20 Years 1852–71; Unmanured since
20 years 1852–71	.	Bushels 20	Bushels $27\frac{1}{2}$	Bushels $48\frac{1}{4}$
25 years 1872–96	.	Bushels $12\frac{1}{8}$	Bushels $16\frac{1}{8}$	Bushels $49\frac{1}{4}$

The above table shows that the effect of the farm-yard manure is very appreciable for at least a quarter of a century. It also shows that when farmyard manure was used every year the yield for the final twenty-five years was greater than in the first twenty years. And also that the increase by using mineral manures without nitrogen is appreciable but slight. The use of rape-cake as an organic manure for barley gave interesting results which are set forth in Table III.

TABLE III.—*Rape-cake as a Manure for Barley 1852–91.*

—	Rape-cake alone	Rape-cake with mixed Mineral Manures and Nitrate of Soda	
		Bushels per acre	Bushels per acre
20 years 1852–71	.	45 $\frac{1}{4}$	49 $\frac{1}{4}$
" " 1872–91	.	37 $\frac{1}{8}$	41 $\frac{1}{4}$

It is to be noticed that the reduction in produce in the second twenty years as compared with the first amounted to more than eight bushels per acre. The

reduction in the second twenty years was, in the opinion of the authors, mainly due to less favourable seasons, but nevertheless it is shown that the yield with farm-yard manure for the twenty-five years 1872-96 was 49 bushels as against $48\frac{1}{4}$ for the twenty years 1852-71. The experiments made in growing clover on rich garden soil are of great interest. This has been done for forty years in a part of the Rothamsted kitchen garden which has been in cultivation for two or three centuries. The average yield for the forty years was $59\frac{1}{4}$ cwt., or nearly three tons of hay, which "would be a very good yield for the crop grown only occasionally in the ordinary course of agriculture." The average yield in the first ten years was much greater than in the subsequent thirty years, and averaged $95\frac{1}{2}$ cwt., and the maximum yield appears to have been about 148 cwt., or nearly seven and a half tons to the acre. In 1857, after the removal of the crops of the fourth year of the experiment, the surface soil nine inches deep contained four times as much nitrogen as the average of the Rothamsted arable soils to the same depth, and nearly five times as much as the exhausted arable land where red clover had failed. The experiments on wheat with artificial manures are equally instructive.

TABLE IV.—*Showing the Yield of Wheat in Bushels per Acre.*

Period	Mixed Mineral Manure—			
	Alone	And NH, 86 lb. N.	And NH, 129 lb. N.	And NH, 172 lb. N for first 13 years (1852-64); un- manured for last 19 years
18 years 1852-64 . .	Plot 5 18 $\frac{1}{2}$	Plot 7 87 $\frac{1}{2}$	Plot 8 89	Plot 16 89 $\frac{1}{2}$
19 years 1865-88 . .	13 $\frac{1}{2}$	29 $\frac{1}{4}$	34 $\frac{1}{2}$	14 $\frac{1}{2}$

In the above experiments we find, no dung being used, that the yield is less in the second period than in the first, and that when the large amounts of artificial manure were withdrawn in Plot 16 the yield dropped almost at once. The authors say: "There is, in fact, abundant evidence to show that there is but little effective manure residue after the growth of a grain crop by the application of ammonium salts; and there is little doubt that the produce of one and a half bushels of grain and its straw per acre per annum more over the nineteen years after the cessation of the application of ammonium salts than on Plot 5 with the mineral manure alone is, so far as it is to be attributed to residue, mainly due to the increased *crop residue*—stubble and roots accumulated during the thirteen years of the application; and much the same may be said of the after-effects when grain crops have been grown with nitrate of soda." Again: "When organic matter, animal or vegetable, is applied to the soil as manure, its complete decay and the complete liberation of its fertilising constituents extend over a considerable period of time. Poor land cannot be suddenly brought into *condition* by the consumption on the farm of purchased foods. Nor can condition—that is, accumulated fertility—be at once withdrawn by suddenly stopping the use of foods."

Food-supply.—Sir William Crookes, the President of the British Association, in his address (Bristol, 1898) drew attention to the fact that if population continued to increase we might expect to be short of wheat. Our remedy was to increase the fertility of the wheat-growing area of the world, and taking, as was perhaps but natural, a purely chemical view of fertility, he put forward the proposition that the productiveness of the

soil might be expected to bear a direct ratio to the amount of fixed nitrogen which is applied to it, and he found comfort in the fact that after the exhaustion of the nitre beds of Chili and the guano beds of Peru, the chemist of the future would be able, by the aid of electricity generated by Niagara and other natural forces, to fix the atmospheric nitrogen for the benefit of the farmer. In the course of his address Sir William Crookes made allusion to the sewage question in the following words:

"There is still another and invaluable source of fixed nitrogen. I mean the treasure locked up in the sewage and drainage of our towns. Individually the amount so lost is trifling, but multiply the loss by the number of inhabitants, and we have the startling fact that in the United Kingdom we are content to hurry down our drains and watercourses into the sea fixed nitrogen to the amount of no less than 16,000,000*l.* per annum. This unspeakable waste continues, and no effective and universal method is yet contrived of converting sewage into corn. Of this barbaric waste of manurial constituents Liebig nearly half a century ago wrote in these prophetic words: 'Nothing will more certainly consummate the ruin of England than a scarcity of fertilisers—it means a scarcity of food. It is impossible that such a sinful violation of the divine laws of Nature should for ever remain unpunished, and the time will probably come for England sooner than any other country when, with all her wealth in gold, iron, and coal, she will be unable to buy one-thousandth part of the food which she has during hundreds of years thrown recklessly away.' The more widely this wasteful system is extended, recklessly returning to the sea what we have

taken from the land, the more surely and quickly will the finite stocks of nitrogen locked up in the soils of the world become exhausted. Let us remember that the plant creates nothing ; there is nothing in bread which is not absorbed from the soil, and unless the abstracted nitrogen is returned to the soil its fertility must ultimately be exhausted."

Sir John Lawes and Sir Henry Gilbert, in a communication addressed to the *Times* on December 2, 1898, point out that even supposing that atmospheric nitrogen could be fixed at a remunerative price, the addition of nitrates without the addition of the other mineral constituents necessary for wheat growing would be of no permanent use ; but they express the opinion that the stores of nitrogen and other fertilising salts existing in our own soils and the soils of foreign countries can be made available by thorough tillage and proper rotation of crops. The land wants labour, and the production of wheat is likely to be proportionate to its market value. They point out that the average wheat production of the *unmanured* plot at Rothamsted (over thirteen bushels) is greater than the average of the whole of the United States, a fact mainly due to proper tillage and thorough weeding.

It is tolerably evident that fertility is not merely a chemical question. The year 1898 was remarkable for a fine wheat crop in this country. The yield is said to have averaged thirty-five bushels instead of twenty-eight or twenty-nine bushels per acre. Sir John Lawes, in his annual letter to the *Times* (October 22, 1898) on 'The Wheat Crop of 1898,' states that at Rothamsted the yield on the experimental plots was as under (p. 102).

TABLE V.—*Wheat Crop in 1898.*

—	Bushels per acre	Owt. of straw
Plot 8, unmanured	12	12 $\frac{1}{2}$
Plot 9, nitrates	28 $\frac{1}{2}$	88 $\frac{1}{2}$
Plot 7, ammonia salts	28 $\frac{1}{2}$	44 $\frac{1}{2}$
Plot 8, " "	29 $\frac{1}{2}$	54 $\frac{1}{2}$
Plot 2, farmyard manure	88	55 $\frac{1}{2}$

In 1898 at Rothamsted the plot dressed with nitrate of soda yielded twenty-three bushels, as against thirty-eight bushels on the farmyard plot, and in explanation Sir John Lawes says : “ For only the second time during a period of more than forty years the wheat plant was much injured where we have used the heaviest dressing of nitrate of soda for want of enough rain to form and distribute a sufficiently dilute solution of it; and a similar result occurred in the year of drought of 1893 ; whilst in this year, 1898, the barley plant was much injured with only half the amount of nitrate applied.” Sir John Lawes also gives the average yield of these five plots for periods extending over forty-six years.

TABLE VI.—*Wheat Crop, 1852–97.*

—	Un-manured	Farm-yard	Ammonia salt	Ammonia salt	Nitrate of soda
86 years 1852–87	18	88 $\frac{1}{2}$	82 $\frac{1}{2}$	86 $\frac{1}{2}$	86 $\frac{1}{2}$
10 years 1888–97	12 $\frac{1}{2}$	40 $\frac{1}{2}$	84 $\frac{1}{2}$	87 $\frac{1}{2}$	83 $\frac{1}{2}$
46 years 1852–97	12 $\frac{1}{2}$	85 $\frac{1}{2}$	88 $\frac{1}{2}$	86 $\frac{1}{2}$	86 $\frac{1}{2}$

From the above table it will be observed that not only has farmyard manure proved to be practically the equal of artificial manures for nearly half a century, but that during the last ten years the yield from it has been considerably more than that of any of the artificially manured plots. It is interesting to observe, also, that

had the wheat-growing area of this country in the year 1898 been sprinkled with nitrate of soda after the manner of Plot 9 at Rothamsted, the yield might have averaged only twenty-three bushels instead of thirty-five bushels. On 2,000,000 acres, which is approximately the wheat area of the United Kingdom for 1898, this means a deficit of 24,000,000 bushels or 8,000,000 quarters. The chemical analysis of a soil often fails to give the clue to its fertility or sterility. Mr. Robert Elliot, in a paper on 'The Value of Plant-roots as Tillers of the Soil,'¹ quotes Sir John Lawes to the effect that "All our experiments tend to show that it is the physical condition of the soil—its capacity for absorbing and retaining water, its permeability to roots, and its capacity for absorbing and radiating heat—that is of more importance than its, strictly speaking, chemical composition." It is, in fact, abundantly evident that the biological side of fertility is quite as important as the chemical, and that organic manures are absolutely necessary to maintain the fertility of the soil, and that of all organic manure there is nothing to be compared with dung. If all that comes from the land be returned to it there can be no reason why the agriculturist should trouble himself with chemical theories. He has only by labour to maintain the soil in a good physical condition and he may rest assured that its fertility will increase.

¹ *Journal of the Royal Agricultural Society*, vol. viii. p. 469.

CHAPTER XII

SANITATION IN HOLLAND

IN Holland the connection of *sanitation* with agriculture is far closer than with us, and it is possible that we may derive some useful hints from our neighbours. In Holland the sanitary problems are of a formidable kind. The level of the country varies from a few feet above to a few feet below the mean level of the German Ocean, and it is needless here to recount how the Dutch people, marvellous for their shrewdness and untiring industry, have maintained a successful warfare against the forces of Nature. With the exception of two or three inconsiderable areas the whole of the Kingdom of the Netherlands is a flat plain intersected at very frequent intervals by canals and rivers. These watercourses are all sluggish and in some of them the slow current is maintained artificially by pumping. It may be said that every Dutchman lives within a few yards of a watercourse of some kind, be it ditch or canal. These canals form a very cheap and admirable means of internal communication, and in consequence the barge population is very large indeed. The population of Holland tends steadily to increase, such increase being most marked in the big towns.

In no country in Europe, probably, has the state of public health improved more remarkably than in

Holland. This is well shown by the following table which is taken from the 'Annuaire Statistique de la Ville d'Amsterdam,' 1896. The decline of the death-rate has been uniform and continuous since 1884, but for the sake of conciseness the years 1877, 1880, and every fourth year thereafter alone have been given.

Nombre des décès (mort-nés exclus) par 100,000 habitants de la population moyenne dans les cinq grandes villes des Pays-Bas, années 1877-96.

Années	Amster-dam	Rotter-dam	s'Graven-hage	Utrecht	Gronin-gen	Les 5 villes
1877	25,00	25,32	21,66	23,91	29,51	24,70
1880	27,00	24,65	23,88	27,10	24,89	25,74
1884	27,87	27,01	24,87	26,38	22,00	26,67
1888	21,82	21,26	20,11	22,56	20,04	21,38
1892	19,78	23,26	20,32	23,84	17,27	20,89
1896	17,77	18,27	16,27	19,04	16,01	17,65

The causes of this improvement in the death-rate are probably the same as have operated throughout Western Europe generally. These causes are: (1) the improvement in the physical and moral condition of the lower strata of society; (2) sanitation in its widest sense; (3) the rapid increase of population, especially in the towns, causing a dilution of the high death-rates in the old crowded portions by the lower death-rates of new settlers in the outskirts; and (4) the decrease in the birth-rates. In Holland, as in England, the importance of pure water, especially for town populations, is abundantly recognised, and public supplies have, within recent years, been carefully protected from pollution and filtered before being distributed. The risk of drinking canal water must have been very great indeed. The mode of dealing with faecal matter is necessarily different from ours. In Holland water-closets are the exception

and not the rule, and while the slop water of the houses is allowed to flow into the canals, the faeces are collected and used for agricultural purposes. During a visit to Holland in September, 1898, I was able to obtain the Dutch death-returns for 1885-89 and for 1889-94, a period of ten years in all. For this I have to thank Mr. Verryn Stuart, the secretary of the Statistical Commission at The Hague, who most courteously procured for me the volumes containing the returns in question.

The Netherlands.

Provinces	1885-1890			1890-94		
	Total deaths	Deaths from typhoid and typhus fevers	Proportion of typhoid and typhus fevers to total	Total deaths	Deaths from typhoid and typhus fevers	Proportion of typhoid and typhus fevers to total
North Brabant .	60,436	245	1 in 247	62,808	257	1 in 244
Guelderland .	53,706	818	1 „ 171	55,713	808	1 „ 181
South Holland .	110,964	563	1 „ 197	112,139	462	1 „ 243
North Holland .	90,959	621	1 „ 146	89,494	713	1 „ 125
Zealand . .	20,456	98	1 „ 220	20,390	125	1 „ 163
Utrecht . .	25,837	186	1 „ 156	26,098	184	1 „ 142
Friesland . .	81,851	263	1 „ 121	80,898	227	1 „ 137
Overijssel . .	83,765	280	1 „ 120	84,145	238	1 „ 143
Groningen . .	25,594	253	1 „ 101	25,988	287	1 „ 110
Drenthe . .	18,658	90	1 „ 152	14,564	107	1 „ 136
Limburg . .	26,852	100	1 „ 263	28,701	125	1 „ 229
Kingdom . .	498,573	2,987	1 „ 165	500,933	2,988	1 „ 168
1885-94						
Kingdom . .	994,506	5,970	1 „ 166	—	—	—

Taking the population for 1885-94 at 4,500,000, the average annual death-rate is 18·26, and the typhoid fever and typhus fever death-rate is 0·18 per 1,000.

It will be observed that in Holland, generally, the death-rate from enteric fever compares favourably with our own. Knowing as we do the great risk of drinking sluggish water liable to faecal contamination (which has

been exemplified in the Tees valley), the low enteric death-rate in Holland is not a little remarkable. Enteric being a fever of slow and insidious onset, it is impossible in sporadic cases to say where or how the patient may have been infected, and in cities with an ever-shifting population this difficulty is accentuated. That being the case it will not be without interest if I give a few particulars concerning the provinces of Groningen and Friesland, which I visited in the vacation of 1898. These two provinces are almost entirely devoted to dairy farming, the breeding of horses and cattle, and agriculture. The shifting and travelling population is a small one, and it is here, if anywhere, that we may learn the effect of local habits and customs on the public health.

The town of Groningen with 63,863 inhabitants is in point of population the fifth town in Holland, and a reference to the table will show that the improvement in its death-rate in the past twenty years has been as remarkable as that observed in the other Dutch cities or in any town or city in this country. In this town as also in Leeuwarden, the capital of Friesland, and in the great majority of Dutch towns, the faecal matter is collected in pails, and it is probable that in the whole extent of the two northern provinces of Groningen and Friesland there is not a water-closet to be found. The whole of the faecal matter is scrupulously and religiously collected and returned to the soil. Dutch cleanliness is proverbial, and certainly I have never been in a town so exquisitely clean as is the town of Groningen. The accumulation of ordure in the streets and backyards is simply not tolerated, and the inhabitants co-operate with the scavengers in clearing away all refuse as quickly as possible. The collection of

faecal matter is very simple. The closet-pails are much smaller than those which are commonly used in this country, and they are emptied twice or thrice a week or daily if the householder is ready to pay a small fee. The collecting cart is really a tank upon wheels with a sort of hood projecting behind like the hood of a carriage facing the wrong way. The pails are brought out, and the man and pail are hidden by the hood as the contents are simply tipped into the tank. The pails even when full being such as one man can lift easily, the collection is probably ten times as rapid as is the case in those English towns which make use of huge two-man pails which weigh 50 lb. and more when empty. Again it is obvious that the Groningen authorities do not make the mistake of hauling about an immense weight of pails, which adds enormously to the expense. The dépôt where the material is collected is on the outskirts of the town, where a wharf has been constructed with a view to its removal by barge for the purposes of the farmer. Here, again, the arrangements are very simple. The stuff is simply stacked beneath rough sheds covered with corrugated iron. The men employed have found out exactly how to do it, and by arranging a layer of street sweepings and rubbish (dung, straw, paper, rags, &c.) with peat ashes (the fuel used in this district is almost exclusively peat) alternately with a layer of pail contents, the whole mass drains and consolidates into a very rich black manure which the farmer highly appreciates. The floor of the dépôt is concreted and provided with channels so that the urine drains away into a large tank whence it is pumped into barges for the use of the agriculturist. Considering the work which went on in it, this dépôt was wonderfully neat, the stacks were as evenly made

as the best hay stacks, and the paths between them were quite free from befoulments. The smell from the putrid draining was, to say the least, powerful, but the solid stuff soon ceases to be very offensive. There were large numbers of flies in this dépôt, but I frequently remarked that the flies in the town of Groningen were not nearly so troublesome as is the case in cities less carefully scavenged.

In the town of Leeuwarden the pails are taken to and from the dépôt, but the pails are much smaller and lighter than those in use in England, so that fifty-four of them (three tiers of eighteen each) can be carried on a one-horse lorry. In the ten years 1885-94 there were in each of the provinces of Groningen and Friesland 490 deaths from enteric fever and typhus fever, 980 deaths in all or an average of 98 per annum in a population of some 600,000, giving a rate for typhus fever and enteric fever of 0·16 per 1,000. During the same period there were 97 deaths from the same cause in the town of Groningen and twenty-seven in the town of Leeuwarden, or 124, giving a yearly average of 12·4. These figures are not large, but they show that as regards these diseases the condition of Groningen was slightly worse than the town of Leeuwarden. As in England so in Holland, the death-rate from enteric fever has been falling steadily, and the returns for the last available year (1897) are very instructive. From these returns I find that in the province of Groningen with 296,521 inhabitants there were 23 deaths from enteric fever in eighteen parishes, giving a death-rate of 0·08, and in the province of Friesland, with 339,425 inhabitants, there were 19 deaths from enteric fever in twelve different parishes, giving a death-rate of 0·056 per 1,000. It is a remarkable and most interesting

produce is exported to this country where (albeit that many a tract of bog and waste moorland is waiting for the subjugation of civilisation) the land under cultivation is tending to decrease, where manorial wealth is being recklessly burnt or turned into the sea, and where one-half of the population is absolutely ignorant of the uses and value of dung and the other half is, if not ignorant, too squeamish to use it.

The municipal accounts of the city of Groningen for the year 1897 show that the total cost of keeping the city clean was 94,596 florins (12 florins = 1*l.*) . The chief items of this expenditure were :

	Florins		Florins
Salaries and wages	50,615	Disinfectants	263
Horse hire	21,441	Sundries	4,177
Repairs to carts	4,507	Clearing snow	11,281
Boat hire	1,500		
Brooms	812	Total	94,596

As a set-off against this expenditure the accounts show that the compost resulting from the stacking of ordure and refuse, which amounted to 1,815 barge-loads, was sold for 58,075 florins, and the liquid manure which drained from the stacks, and which is much valued by agriculturists, was sold for 5,839 florins. The total receipts from the sale of manure amounted, therefore, to 63,914 florins, which, deducted from 94,596, gives 31,182 florins (say 2,600*l.*) as the net cost of cleaning Groningen. Taking the population of Groningen at 63,863, the cost of scavenging works out at something less than half a florin or 10*d.* per head of the population. It will be noticed that of the total expenditure (exclusive of clearing snow) very nearly two-thirds go in wages, a great part of which is paid to the poorest class and must in some degree lessen the poor-rate. It appears that the permanent staff consists of 102 persons,

of whom fifty-six with twenty-eight horses and carts are engaged mainly in collecting ordure, and twenty people with ten horses and carts in collecting ashes and refuse. For cleaning sewers, canals, gutters, and gratings nineteen men are employed. The collection of ordure is done in the early morning before 10 o'clock.

CHAPTER XIII

CARRINGTON MOSS

THIS seems to be the place in which to allude to the spirited action of the city of Manchester, which has reclaimed Carrington Moss and which is reclaiming Chat Moss by fertilising the ground with the organic refuse of the city. The ground is a virgin peat which is admitted to be deadly to one at least of the supposed earth organisms. The experiment is a splendid one, and will certainly be the precursor of similar action elsewhere. I have gathered some figures which may give an idea of the gigantic task with which the Cleansing Committee of the city have to grapple. From the report of the Cleansing Department of the city of Manchester for 1897 I find that 354,964 tons of refuse—very nearly 1,000 tons a day—were disposed of. Stated in cartloads there were of street sweepings, 61,248; of 'Bell dust,' 9,828; of rubbish, 97,658; and of night-soil, 240,781; total, 409,510. Of the material collected nearly one-third of the weight is lost by evaporation (in the preparation of concentrated manure), leakage, and drainage, and nearly 100,000 tons find their way to the rubbish tip, so that about 140,000 tons remain to be accounted for. Of this 49,342 tons were sent to Carrington Moss, and over 57,000 tons were disposed of to farmers direct. Over 6,000 tons of concentrated manure (made from 108,000 tons of 'day-soil' or pail-

closet contents) sold for more than 17,000*l.* Nearly 19,000 tons were converted to mortar, and were sold for 4,500*l.*, and some 9,000 tons of clinkers were used for road-making. The net expenditure of the Cleansing Committee in 1897 amounted to 131,793*l.*, so that the 354,364 tons of refuse were dealt with at a cost of 7*s.* 5*d.* per ton. The total cost for the year of the Carrington estate (including rent and interest of capital) was 2,482*l.*¹ The material sent to Carrington in 1897 consisted of 37,082 tons of nightsoil, 587 tons of sweepings and garbage, and 11,673 tons of cinders. The Carrington Moss estate, therefore, regarded merely as a dumping ground for garbage and refuse, must be a source of satisfaction to the Cleansing Department of the city of Manchester.

On August 11, 1897, I visited Carrington Moss, and had the advantage of being shown over it by Mr. McConnell, the bailiff. Carrington Moss was bought by the Manchester Corporation in 1886. It is ten miles from the city, in close proximity to the famous Chat Moss, from which it is separated by the Manchester Ship Canal, which serves for the transit of material from Manchester. The estate, for which the Corporation gave 88,000*l.*, has an extent of 1,100 acres, of which 600 were wild moss commanding a rental of a shilling an acre for sporting rights. The Corporation has spent 56,000*l.* on light railways, roads, drainage, rolling-stock, buildings, &c., making the cost 94,000*l.* (The outlay on the estate is given as 82,946*l.* in the City Treasurer's Abstracts, 1897.) In the nine years 1889-97, 491,686 tons of refuse material have been placed upon Carrington Moss, or very nearly fifty tons per acre per annum.²

¹ In the year ended March 31, 1901, the net cost was 861*l.* 15*s.*

² In the thirteen years ended March 1901, the total is given as 689,779 tons.

The moss has been drained by a series of deep trenches with nearly vertical sides cut at regular intervals. The refuse as it arrives from Manchester is transmitted by means of a light railway to various parts of the estate, where for the most part it is placed in heaps and allowed to 'ripen' before being placed upon the ground. These heaps soon cease to be in the least offensive. Nightsoil is frequently applied directly to the fields. At the time of my visit two barges, estimated to contain eighty tons of refuse, were unloading at the little wharf which has been especially constructed. The hay harvest was just over, and the corn harvest was soon to commence. The crops one and all were in splendid condition. Oats, potatoes, carrots, wheat, and all the other usual farm crops appeared to be first-rate, quality excellent, quantity enormous. The roads were hard and firm, having been brought to this condition by the application of clinker and other forms of hard material from the city. The farm is not quite a dead level, but the inequalities of the surface are very slight, so that from every point the spectator is able to survey an area of very considerable extent. Without previous knowledge there was nothing in the appearance of the farm (except the deep trenches) to indicate the character of the subsoil. All indications of bog had completely vanished. On reaching Mr. McConnell's house we walked out upon a pretty lawn surrounded by a flower-border brilliant with carnations and the ordinary garden plants. The lawn was firm and perfectly dry, and I was not prepared for the demonstration which I was to have of the character of the subsoil. Taking an iron rod having a length of $11\frac{1}{2}$ feet and a diameter of about half an inch, Mr. McConnell with one hand drove it through the turf of his lawn completely up to the handle. I then did the same thing.

As the rod passed through the first foot or so there was some resistance and a sense of grittiness was imparted to the hand, but, this first obstruction passed, the descent of the rod was progressively easier until it was finally stopped by the handle resting on the lawn. On withdrawing the rod the lower half was found to be wet while the upper part was dry. To the upper half clung a little grit and peaty earth, the lower half was clean but wet. It was then only that one recognised that this fertile paradise was literally floating.

Mr. McConnell informs me that Carrington Moss is everywhere about twelve feet in depth and that the variations in depth are very slight; whereas Chat Moss, although distant only a few miles, has a depth which varies from four to over thirty feet. On Chat Moss, where the digging of drainage trenches was in progress, I examined the peat which had been removed. These trenches are dug to a depth of about four feet to begin with. The peat near the surface had the ordinary fibrous character, whereas that from the bottom appeared to the naked eye to be smooth and structureless and saturated with moisture. It looked like brown jelly. The moss resembles a huge sponge. Mr. McConnell states that the surface of Carrington Moss is gradually sinking; that whereas when first he came to live on the estate he could from a certain point see the spire only of a neighbouring church, he can now see the slates upon the roof. The sponge is being squeezed and drained, and rendered more compact. The half million tons of garbage which has been placed upon the surface must exercise considerable pressure and must serve to squeeze moisture into the deep trenches. Then, again, the upward drainage of the abundant crops is obviously very large indeed. The amount of moisture retained

and evaporated by an acre of oats or mangold must be very great.

There are, as yet, not many trees upon the estate, but part of it—about forty-three acres—is used as a nursery for the shrubs required for the parks and cemeteries of Manchester. These nurseries appeared to be most flourishing and contained a large variety of shrubs. The rhododendrons were extremely vigorous. Mr. McConnell assured me that the farm as a place of residence is by no means damp, and that the rain which falls upon his lawn quickly drains away to the reservoir beneath and leaves the surface dry. He and his family and the employés on the farm have always enjoyed excellent health. There has been one case of enteric fever in nine years, the cause of which is doubtful.

Of the 1,100 acres of land occupied, 1,011 acres are let to tenants, and the rest is occupied by roads, wharves, plantations, &c. On July 30, 1900, I paid a second visit to Carrington Moss and I embodied the impressions made upon me in a letter to the *Times*, from which the following extracts are taken :

“ Let me say emphatically that Carrington is not a ‘sewage farm.’ The muck is dry, and is spread on the surface of the land and ploughed in in the ordinary way. There is no excess of water. Sewage farming in which the living humus is drowned by tons of water leads surely to agricultural bankruptcy.

“ At my visit in 1898, and again in July of this year, I had ocular proof of the fertility of this reclaimed land. The hay harvest was just over, and had been a good one, and the standing crops of wheat and oats, potatoes and carrots, would be hard to beat in any part of England. The wheat was especially good, and one

field of 17 acres, which Mr. McConnell, the manager, estimated would yield over forty bushels to the acre, was certainly the finest I have ever seen. Much of the land is now passing into the hands of nurserymen and market gardeners. The ornamental shrubs (except conifers, which have no appetite for manure) were in splendid condition, and I am told that these nursery gardens are exceptionally brilliant when the rhododendrons are in bloom. The physical change which has taken place in this bog as the result of the agricultural and other operations which have been carried out upon it is very interesting. The downward drainage by the deep trenches, and the upward drainage by the heavy crops, which to a large extent prevent the rain from percolating, have resulted in the sinking of the surface and the general compression of the bog so that the land tends steadily to get firmer. Formerly, when ploughing, it was necessary to put 'pattens' upon the horses' feet in order to prevent them from getting 'bogged,' but this necessity, I was informed, now seldom arises.

"The farmhouse at Carrington stands on solid and deep foundations, but that the land around it is gradually sinking is well shown by the fact that it is found necessary to provide an additional step for the door at recurring intervals. Between 1898 and my late visit a new step had been placed. At my visit in 1898 Mr. McConnell, who then occupied the farm at Carrington, gave an interesting demonstration of the character of the soil by driving an iron rod, $11\frac{1}{2}$ feet long and half an inch in diameter, vertically through the turf of his lawn up to the handle. I easily did the same thing, for the rod having passed the first foot or so met with little resistance, and when withdrawn was found to be streaming with moisture. Mr. Carter, the present

occupier of Carrington, kindly allowed me to repeat the experiment at my late visit. I managed with some difficulty to drive the rod into the soil for about 8 feet, but the increasing resistance prevented one from driving it completely 'home.' When withdrawn, the rod was not wet, but was coated with moderately moist soil. The rapid desiccation and consolidation of the moss was thus made evident.

"I would respectfully suggest to the Corporation of Manchester that this great experiment merits systematic observation by men of science. A few 'surface' wells for the periodic examination of the water by chemists and bacteriologists are much to be desired, and the changes of earth temperatures, the progressive alterations in the physical condition and the flora and fauna of the soil ought to be systematically recorded.

"The success attained at Carrington Moss has induced the Corporation to purchase some 2,500 acres of Chat Moss, which is now being subdued under the experienced guidance of Mr. McConnell, so that, eventually, the Corporation will be in possession of a fertile estate of 3,600 acres. Allowing 10 per cent. for roads and other works, they will have about 3,240 acres under cultivation, or land capable of producing annually 18,000 quarters of wheat and 8,000 tons of straw where none grew before. Assuming that the land is capable of receiving twenty tons of refuse per acre *in perpetuo*, the city will be in possession of a 'destructor' capable of consuming about 65,000 tons of organic refuse per annum, and each ton of refuse will ultimately return about a bushel and a half of wheat and 2½ cwt. of straw (the chief ingredients for 100 lb. of bread and perhaps 1,000 straw hats).

"This, surely, is better than burning or fouling rivers.

This Manchester experiment should set us all thinking. Is there no possibility of bringing about a profitable interchange of produce between the great cities and the unreclaimed bogland of Ireland? Is there not here a lesson for the consideration of every village council throughout the kingdom—a lesson which has been taught, not by the Utopian dreamer, but by hard-headed men of business?"

The accounts of the Cleansing Department of the city of Manchester for the year ending March 31, 1900, show that the Carrington estate yielded 777*l.* 5*s.* 2*d.* in excess of expenditure and that Chat Moss yielded an excess of revenue over expenditure amounting to 2,591*l.* 13*s.* 4*d.* The interest on loans (capital account) was for Carrington 2,036*l.* and for Chat Moss 4,896*l.*, so that the net cost of these two estates amounted to 3,563*l.* 1*s.* 6*d.* The amount of material sent to these estates in the year was 88,300 tons.

I am well aware that in farming, where results depend so largely upon the weather, it is hazardous to calculate returns on the yield of a single year, and that anything under a ten years' average is likely to mislead. On the other hand, 10*l.* worth of produce from an acre of land is no excessive return. My visit to Carrington Moss left upon me the impression that much of the land is ready to pass, as some has already done, from the hands of the farmer to those of the market gardener. In that case, when oats, grass, and carrots and mangels give place to fruit and high-class vegetables, it is certain that, with a market like Manchester at its door, the money value of the crops in Carrington Moss may be doubled or quadrupled. There is probably no city in the world where excreta are dealt with by methods other than water-carriage on so large a scale as they

are dealt with in Manchester. In 1897 the city had an area of 12,911 acres; it contained 534,299 inhabitants living in 105,728 dwelling-houses, or rather over five persons to a house. There were 76,913 pail-closets, presumably used by some 384,565 persons, who provided 189,585 tons (nearly 425,000,000 lb.) of 'pail contents.' It would appear from the Cleansing Committee's accounts (p. 36) that at the Holt Town Works 108,894 tons of 'day soil' were converted into 6,804 tons of concentrated manure, and that for the production of this manure were used 4,897 tons of coal and coke and 1,674 tons of chemicals. Adding the weight of the chemicals to the weight of the 'day soil' we arrive at the fact that 110,068 tons of raw material and chemicals were reduced to 6,804 tons by the aid of 4,897 tons of coal. Or we may say that 6,571 tons of fuel and chemicals produced 6,804 tons of manure from 108,894 tons of raw material. The amount of water and other volatile matter driven off amounted to 103,764 tons. The price paid for chemicals (5,098*l.*) and fuel (675*l.*) amounted to 5,773*l.*, while the net profit on the sale of manure amounted to 2,081*l.* (p. 15).

It is instructive to compare the Holt Town Works concentrated manure accounts (pp. 14-15) with the Carrington Moss Farm accounts (pp. 28-31). At the former a turnover of 30,533*l.* resulted in a profit of 2,081*l.*, or rather more than 6½ per cent., while at the latter a turnover of 6,202*l.* resulted in a profit of 1,041*l.*, or very nearly 17 per cent. Turning to the City Treasurer's Abstracts we find that whereas the Holt Town Works (p. 50), upon which the outlay has been 111,318*l.*, are now valued at 71,429*l.*, the Carrington Moss estate, upon which the outlay has been 82,946*l.*, is now valued at 118,617*l.*, so that while 39,889*l.* of capital have been lost at Holt Town, 35,671*l.* have been made at Carrington.

CHAPTER XIV

CONCLUSIONS

I HAVE brought forward a considerable number of facts to prove that the dangers of applying dung to the soil are as nothing in comparison with the advantages—advantages which have been acknowledged from the dawn of historic time till now. It remains to say a few words on the financial side of the question. The great experiment at Manchester seems to prove conclusively that even in a huge city and with the heavy outlay which seems to be inseparable from all modern municipal undertakings a well-considered scheme of application of offal and ordure *in a dry state* to the soil is the most economic way of getting rid of it. I have shown how in Holland great cities may be kept spotlessly clean and in spite of obvious difficulties the public health be maintained by a well-devised system of scavenging. The cleanliness of Groningen is a thing which is scarcely realisable by one whose ideas of street sanitation are acquired in the West End of London, and the economy with which the scavenging is accomplished seems astounding to the London ratepayer. I have further shown that Holland, with a smaller area of cultivated land in proportion to population than England, is able to export to this country enormous quantities of farm and dairy produce, and that while the English farmer

can scarcely exist the Dutch agriculturist thrives and grows rich.

It will not be uninteresting, perhaps, if I give some of the results of my small experiment at Andover, which is now in its fourteenth year of trial. In this experiment the ordure and house refuse of about 100 persons have been removed and applied *daily* for gardening purposes. The amount under the spade is now exactly one acre, one rood, and seven poles, and I should like to say that the quantity of faecal matter at the disposal of my gardener by no means satisfies him. I am also convinced that the garden might take with advantage at least double the quantity if not more. There is no evidence, after a long experience, that the soil is overdone. On the contrary, its 'condition' has steadily improved.

As to the financial results, the produce of my garden has been sold on the principle of profit-sharing, so that the gardener is interested in extracting the greatest amount of produce from the soil. During the past year (1889) careful accounts have been kept, and I find that the produce fetched 71*l.* 19*s.* 6*d.*, which works out to 56*l.* per acre. Of this sum 41*l.* 12*s.* 7*d.* were received for fruit, and 30*l.* 6*s.* 11*d.* for vegetables. Some of the chief items were as follow: Apples and pears, 18*l.* 0*s.* 6*d.*; summer fruit, 17*l.* 1*s.* 11*d.*; peaches (outdoor), 8*l.* 19*s.* 2*d.*; potatoes, 6*l.* 3*s.* 4*d.*; cabbage and cauliflower, 5*l.* 18*s.* 8*d.*; tomatoes (outdoor), 2*l.* 3*s.*; asparagus, 2*l.* 1*s.* 1*d.*; and flowers, 2*l.* 2*s.* 5*d.* The method of agriculture which I pursue is well known, but this has caused no prejudice against the garden produce, which finds a very ready market.

In the middle of my garden is a well, which affords a guarantee that no faecal matters are washed downwards

to the subsoil water. This well, which was made mainly for experimental purposes, is very shallow, little more than a dip-hole. The bottom is five and a half feet from the surface of the ground; the sides are lined with concrete pipes to the very bottom, and around these four inches of concrete have been run in in order to give additional protection. There is a good parapet and a movable cover. The well was made in 1891, and the bottom and sides look as clean to-day as when they were made. No water can possibly enter this well except through the bottom, and I drink the water without any hesitation or misgiving because I know there are no leaking sewers or cesspools in the immediate vicinity. The only pollution this well gets is from insects, which creep under the cover. I value the movable cover because it gives me the power of inspection, but I have not been able to keep the insects out. These are chiefly wood-lice and spiders. When it is remembered that the depth of water in the well is only three and a half feet (the water rises to within two feet of the surface of the ground), and the diameter two and a quarter feet, and that the quantity of water standing in the well is not more than some ninety gallons, it is obvious that a colony of wood-lice might easily affect an analysis.

One day while removing the cover of the well, my gardener, before I could stop him, squashed some of the wood-lice which he found, between his thumb-nail and the inside of the cover. When the cover of this well is taken off on an autumn morning one finds much condensation on the inside of the lid. The water is vaporised by the heat of the day, and is condensed on the inside of the lid in the cold morning, and when the lid is taken off these condensed drops flow back into

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Although we cannot compare the 'oxygen absorbed' in 1901 and 1892, it may be advisable to quote from the reports on the quality of the London waters as given in the 'weekly returns of the Registrar-General.'

Thus, in November 1901, Dr. Thorpe gives the 'oxygen consumed' in four hours at 80° F. (mean) by the water of the West Middlesex Company, which I have drunk for over thirty years, as .068, which exceeds the figure given by the Andover well.

In January 1902 the average of the mean results for the West Middlesex water was .112. The other figures in the analysis of the West Middlesex water, so far as they are comparable with those of the Andover water, are :

	Nov. 1901	Jan. 1902
Organic nitrogen . . . . .	.017	.028
Nitrogen as nitrates and nitrites . . . . .	.167	.302
Chlorine	1.85	2.0

The water of the Kent Company, taken from a deep chalk well, is used as a standard of purity by the present official analyst (Dr. Thorpe), as it was by his predecessor (Sir E. Frankland). It becomes of interest therefore to state the facts (in so far as they are comparable with the Andover water) of recent analyses.

Deep Well of the Kent Company

	Nov. 1901	Jan. 1902
Organic nitrogen . . . . .	.009	.006
Nitrogen as nitrates and nitrites . . . . .	.439	.664
Chlorine	2.2	3.8
Oxygen consumed after four hours at 80° F.—mean . . . . .	.004	.008

The interesting facts in these last analyses are the fluctuations in the nitrates and nitrites and the chlorine.

The analyses 1892 and 1901 of my well show not only that the water is one of fair quality, but they further show :

1. That the quality has not deteriorated in ten years.

2. That the faecal matter which has been freely placed upon the humus surrounding the well is all oxydised before it reaches the 'ground water' whence the well is supplied.

The bacterioscopic analysis of this water, carried out by Dr. Houston for the Royal Commission, showed that one cubic centimetre of the water gave 1,400 bacteria on gelatine at 20° C., and 280 on agar at 87° C. Evidence of *Bacillus coli* (or closely allied forms) was obtainable from 1 c.c. but not from .1 c.c. The indol reaction was obtained from 1 c.c., but not from .1 c.c.

The tests for *Bacillus enteritidis* sporogenes gave negative results.

Dr. Houston adds a note to his analysis to the effect that "These samples were examined by the ordinary methods used in the bacteriological examination of sewage and sewage effluents. But in the bacterioscopic examination of potable waters special measures should be adopted (for example the 'Pasteur filtration method'). This procedure was not carried out in the present case. The negative results must therefore be interpreted as only implying relative, not absolute safety for drinking purposes. The presence of *Bacillus coli* in 1 c.c. points to animal pollution. Its absence from .1 c.c. shows that the contamination was not gross in amount."

There has been an increase of bacteria in the water of this well since it was examined by Dr. Cartwright Wood in 1895. How far is this due to the circum-

stances alluded to above? Will spiders, wood-lice, earwigs, and water-fleas furnish bacteria of the coli group? This seems to me a question which must be answered.

Except in the vacation I certainly do not visit Andover more than once a month. My experience leads me to say that it is to me almost inconceivable that the daily scavenging of our towns should not yield enough profit to pay the wages. It is especially to be noticed that the yield of this garden has undergone steady increase, and I have every hope that such increase will continue. But it would be a great mistake to suppose that an acre of ground, cultivated and manured as my garden is, is going to yield 50*l.* worth of produce per annum at once. The test of true gardening is *increase*. With the lapse of years, and without appreciable cost, the increase of fruit trees is automatic, and the yield of seeds is equally automatic and prodigious. My garden has gradually become fully furnished, and to a large extent with its own offspring; and in that fact lies part of the secret of its increasing yield. What we see in the London parks in the summer is not 'gardening' but a beautiful display, after the manner of the *bouquetière*, of the results of gardening elsewhere. In the same way the filling of flower beds with a crowd of named and fashionable plants bought for the season is not gardening but a mere evidence of wealth. The real gardener in these cases is the nurseryman.

The gradual increase in the yield of a plot of land, at least for a very long series of years, is limited only by the amount of skill and tillage which it receives and the amount of dung which is available for it. All evidence goes to show that organic manure in the

form of dung is absolutely necessary for the maintenance of the fertility of the soil. We are gradually becoming alive to the fact that fertility is a biological question rather than a chemical question. To imagine that chemicals can ever replace dung is a pure delusion from which we shall some day be aroused. The success or failure of agriculture is very largely a question of dung, and it must be admitted that the dung prospects in this country are very bad indeed. Imported animal food yields very little dung for the land because it is mostly washed (ultimately) into the sea, while steam-engines and motor cars and bicycles must mean a diminution of horse-dung. The sanitary pioneers of half a century ago thought that the huge expenses of modern sanitation would be compensated by the yield from sewage farms. That has proved to be a delusion. Sewage has proved to be merely the happy hunting ground of sanitary tradesmen who have fattened on the ratepayer. The nineteenth century closed with the spectacle of a Royal Commission still discussing the best way of *destroying* the potentialities of life and prosperity.

In these lectures I have brought forward many facts to show that there is no proof of any danger arising from the use of dung for agricultural purposes, while it is undeniable that the practice of agriculture is pre-eminently healthy and invigorating. I have been unable to find any evidence that contagia spread in the soil. To live in filth and to inhale the products of putrefaction given off from privies, or pails of faeces, or sodden ground, results in disease, but there is no evidence whatever that disease thus generated is able to spread through the soil and infect a neighbouring house or street. Looked at in another way we must admit that filth disease, like many other forms of

disease, is proportionate to overcrowding. We may pave the backyard and provide it with a trapped gully (not always sweet) and we may wash the faeces into a ventilated sewer, which then delivers part of its vapours near our bedroom windows. It is a difficult problem, and there are *pros* and *cons*.

While we exult (not always reasonably) in our diminished death-rate, let us not forget the diminished birth-rate, the multiplication of asylums of various kinds, and the steady increase in the amount of help from public funds which is necessary to maintain the health and decency of the masses. The year 1899 has been unsurpassed in the volume of trade and in the bounty of the harvest, but the infant mortality in our towns for the Michaelmas quarter was the highest on record. Yes ; there are *pros* and *cons*. At present he who advocates any attempt to entice a fair proportion of the people 'back to the land' is regarded as a Utopian dreamer. I feel convinced that the only chance of getting a living from agriculture lies in the due enrichment of the soil. There is no chance of this so long as the only form of sanitation which receives any official encouragement is one which involves a systematic starvation of the soil. One sometimes comes across statements which would lead one to suppose that cultivated land is a public danger—statements which are mere assertions. Some of our sanitarians, careless of food supply, are liable to be dominated by stereotyped ideas, and to fix their attention unduly upon one side of a question and upon one disease. The more enthusiastic of them, if they can secure a trifling diminution in the mortality of one disease, seem quite ready to 'make a solitude and call it peace.'

CHAPTER XV

ENTERIC FEVER¹

POLLUTION OF PUBLIC WATER-SUPPLIES : AT THE SOURCE, IN THE COURSE, AND AT THE PERIPHERY

THE Registrar-General's returns show that the death-rate from enteric fever, which was ·322 in 1871-80, had fallen to ·200 in 1881-90.

Our satisfaction at this decline is seriously qualified by the fact that the tendency of towns to suffer from epidemics of the disease seems to be as great, if not greater than ever. At present (1898) there are three towns (Maidstone, King's Lynn, and Ligoniel, a suburb of Belfast) in which enteric exists in epidemic form as a result of the pollution of the public water-supply. Maidstone has had an amount of enteric fever in the last three months which, under ordinary circumstances, should have been spread over twenty-five or thirty years, and it is evident that this is a calamity of a kind which is not compensated by a decline in the endemic death-rate. I have collected for the purpose of this discussion short records of forty-six instances in which pollution of public water-supplies has taken place, resulting in outbreaks of enteric fever, more or

¹ Being the opening address of a discussion on the subject of the Prevention of Enteric Fever, delivered before the Royal Medical and Chirurgical Society, London, on November 28, 1898 (see also chapters xvi. to xviii.).

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less severe. In thirty of these outbreaks the number of persons who suffered is given, and I find they amount to 16,576. I am, therefore, well within the mark when I say that for the last thirty years considerably more than 500 persons per annum have suffered from enteric fever as a result of the pollution of public water-supplies.

I am mainly indebted for my information to the reports made to the chief medical officer by the inspectors of the Local Government Board. These reports are among the *chefs-d'œuvre* of English medical literature, and one hopes that they may be at some time re-edited and made more available, than at present is the case, to the great bulk of the profession. For six of the cases which I have tabulated I am indebted to the 'Tabular Analysis of Water-borne Typhoid,' lately published by Mr. Ernest Hart.

The contagion of enteric fever is contained in the excreta of the patient, and it is conveyed to the healthy person in his drink or in his food, and probably in the air he breathes. When enteric fever has occurred in epidemic form, the poison has usually been conveyed by water, often directly, and only less often indirectly, through milk or other beverages. In order to keep my remarks within bounds I shall not further allude to milk epidemics.

The following is a brief tabular statement of the Contamination of Public Water-supplies, 1867-97:

Date	Name of Town	Source of Supply	Where Polluted	No. of Persons Attacked
1867	Guildford	Chalk well	Source and course	250
1870	Warwick	?	?	—
1878	Sherborne	Wells	Periphery	248

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Date	Name of Town	Source of Supply	Where Polluted	No. of Persons Attacked
1874	Lewes	Wells	Course	486
"	Hull	?	"	526
"	Over Darwen	"	"	2,035
1876	Tideswell	"	"	—
1878	Dewsbury	"	Source and course	600
1879	Okehampton	"	Periphery	—
"	Swansea	Upland	Source	640
"	Caterham, &c.	Chalk wells	"	352
1880	Enfield	?	Periphery	—
"	Haverfordwest	"	Course and Periphery	—
"	Sandown	Stream	Source	—
"	Ventnor	?	Course	—
"	Llanelli	Stream	Source	—
"	Perth	River	Course	162
"	Newlyn	Well	Source	—
1881	Blackburn	—	Course	238
"	Bodmin	—	Periphery	—
1882	Bangor	—	Course	548
1883	Hitchin	Well,	Source	—
1884	Sheerness	—	Course	—
"	Kidderminster	Well	Course	1,200
"	Beverley	Chalk well	Source	231
1885	Faldingworth	Well	"	—
"	Fareham	—	Course and periphery	150
"	Swansea	Upland	Source	549
1887	Margate	Well	"	—
1887-8	Mountain Ash	—	Course and periphery	518
1888	Buckingham	—	Course	—
1889	Longton	—	?	155
"	Rochester	—	Periphery	—
1890-93	Houghton-le-Spring	Well	Source	258
1890-91	Newark	River	"	297
1891	Tees Valley	"	"	1,468
1891	Rotherham	Streams	"	211
1891-2	King's Lynn	"	"	226
1892-3	Chester-le-Street	"	"	58
1893	Atherstone	?	Course	112
"	Paisley	Upland	Source	672
"	Worthing, &c.	Wells	Source and course	1,411
1894	Newport	"	Source	516
1895	Raunds	"	"	129
1897	Maidstone	Springs	"	1,890
"	King's Lynn	Rivers	"	450

Of these forty-six instances of pollution of a public water-supply it will be noted that in three cases the water was polluted both at its source and in its course, and in three cases in its course and at the periphery. In twenty-one cases it was polluted at its source alone ; in twelve cases it was polluted in its course alone ; in six cases it was polluted at its periphery alone ; in four cases the fact is not stated.

Of the twenty-one instances in which pollution occurred at the source it was shown that of such polluted sources eleven were wells, seven were streams and rivers, and three were upland sources.

These streams and rivers had been polluted by the water-carried excrement flowing into them through the drains and sewers of places higher up, and in some few instances by the falling in of excremental matters from the banks or from boats and barges. Every river and stream in the country is more or less polluted in one or other of these fashions. This fact is too familiar to need further comment.

The mode of pollution of the wells is of more importance.

Three of these polluted wells are of a common type, *e.g.* at Newlyn, Faldingworth, and Raunds, where the wells were polluted quite in the ordinary domestic way by the leakage into them, from neighbouring drains, of foul liquid, either from closets or washhouses where linen fouled by enteric had been washed. In the cases of Guildford, Caterham, Beverley, Hitchin, Margate, Worthing, and Newport, we have instances of the fouling of deep wells in the chalk. A deep chalk well is generally considered a safe source for water, and some appear to think that safety is proportionate to depth. It seems necessary to say that depth is no protection against the effects of leakage at any point, for leakings

must fall to the bottom. It is necessary also to say that the difficulties of inspection are very largely proportionate to the depth. Again, as leakage may occur at any point in the walls, the area of the walls is in some sense a measure of the vulnerability of the well. The chemist and bacteriologist may report with regard to a particular sample taken at a particular time that the water is 'of excellent dietetic quality, well suited for the supply of a town,' but the merest tyro in well-sinking might point out the dangerous position and formation of the well.

With regard to these wells the following particulars may be given :

1. At *Guildford* the pollution of a new chalk well was caused by the leakage into it of quantities of sewage from an old ill-constructed sewer.

2. At *Caterham* an adit over 400 feet below the surface was definitely fouled by a workman suffering from enteric, who deposited his evacuations in the tunnel. The investigation of this classic case was carried out with remarkable acumen by Sir Richard Thorne. The following are the facts :

1879. *Red Hill and Caterham* (Dr. Thorne Thorne).—352 cases caused by a labourer who was working in the adit of the water company, and who was suffering from enteric at the time, actually depositing his evacuations in the tunnel. The evidence shows that he began to be ill on January 5, and that he continued to work in the adit until the evening of January 20, when he was too ill to continue. The adit was therefore possibly fouled with enteric evacuations for sixteen days, and possibly in increasing amounts. The epidemic began on January 19, and, reaching its climax on February 1, came to an end about a month later.

Although I think that Sir Richard Thorne clearly demonstrated the true source of the enteric contamination, it was nevertheless shown that the Caterham wells (three in number, sunk for some 400 or 500 feet through clayey gravel and chalk, and with borings going to a greater depth) were seriously liable to contamination through fissures. Thus on one occasion "waste water was pumped into a hollow spot about 170 feet to the east of the wells; here it disappeared, but it was soon ascertained to be returning into the wells at a depth of 420 feet." The formation in which the wells were sunk was, indeed, dangerously fissured in all directions, and there were cesspools at various spots round the works.

3. At *Beverley* the well (383 feet deep) was alongside a sewage farm belonging to the East Riding Asylum, and from an irrigated field sewage is supposed to have trickled down the well shaft. Here we have an instance of sanitary works carried out for the benefit of one community causing serious trouble to their neighbours; and other instances of this have occurred.

4. At *Hitchin* we are told that defects in the water-works permitted occasional back-flow of sewage-polluted river water into the pumping well.

5. At *Margate* the well was exposed to contamination by soakage from sea water and from cesspools.

6. At *Worthing* we have a leakage of a sewer into a heading run from the bottom of a deep chalk well.

7. At *Newport* (Isle of Wight) the chalk wells were fouled by an adjacent pond, and probably by more distant leaking cesspools, of which there were many. This water contained the *Bacillus coli*, and I trust we may learn in this discussion what is the true value of that fact.

The eighth case of the fouling of a deep well occurred

at Herrington, near Houghton-le-Spring, and the following are the facts :

1889. *Houghton-le-Spring* (Dr. David Page).—258 cases occurring in a population of 4,400 situated within the area of the Herrington water-supply.

The supply was from a well 380 feet deep, through 'clay with sand partings in seams' (72 feet); limestone marl (15 feet); and for the rest through sandstone and shale. The sides were lined with bricks set in mortar, and it was believed to be impervious.

On examination the sides of the well were defective, and a 'feeder' was found discharging into the well 45 feet below the surface.

Microscopic examination of this water afforded evidence of contamination with household refuse, and the source of contamination proved to be a farmhouse containing a water-closet, situated three-quarters of a mile off, and draining into the well through a fissure in the magnesian limestone caused by the subsidence of a colliery beneath.

On examination the pipes of the Herrington service were found excellently jointed, but the sewer pipes were leaking.

This case is one of very great importance. The water company here was free from blame; the pollution was due to what may be called a pure accident.

It is well to call attention to this case, because the deep tunnelling which is going on, and which is being proposed, in London may not be without its effects upon the network of pipes above.

These facts lead one to make a few remarks as to sources of water. Enteric fever being essentially a human disease, the chances of getting water impregnated with enteric at its source must bear direct ratio to the

density of population round that source. On that account there is just now a rush for gathering grounds which are uninhabited. Some of these moorland waters are not without their disadvantages, and we know very little as to the comparative receptivity for poison in hard or soft waters in the presence of enteric excreta. In the above list there are three instances (Swansea [2] and Paisley) of contamination of upland waters.

I find in Glasgow, which enjoys an unlimited supply of the purest water in the world, that in the ten years 1881-90 the enteric fever death-rate was .25 per 1,000 living. The enteric death-rate for 1881-90 for England and Wales was .20, and for London .19. The figures seem to show that Glasgow, in spite of its pure water, enjoys no immunity from enteric fever.

With regard to the relative advantages of wells and springs (captured and enclosed) as against rivers, there are certain obvious facts which must not be forgotten. If a well or spring be fouled, the whole of the fouling is mixed with the water and supplied to the houses. There is, so to say, no escape for accidental pollution except into the water-pipes. Given the fact of fouling, wells and springs are likely to deliver a dangerous dose. A well, in this respect, is analogous to the 'dead end' of a water main, which is always a dangerous spot in case of fouling. If a river be fouled, more or less floats away or passes by the intake. I need hardly allude to the obvious fact that the water in a river is exposed to fresh air and sunlight, while the water in a well enjoys no such advantage.

There were eighteen cases in which a public water-supply was polluted in its *course*, that is, in its transit between the source and the houses, viz. at Guildford, Tideswell, Dewsbury, Haverfordwest, Ventnor, Black-

burn, Bangor, Sheerness, Kidderminster, Mountain Ash, Lewes, Hull, Over Darwen, Perth, Fareham, Buckingham, Atherstone, and Worthing. - Of these eighteen cases, one (Bangor) was caused by fouling of the filter-beds, and two (Haverfordwest and Ventnor) were due to fouling of the reservoirs. The other fifteen were practically due to the same cause, viz. *the in-suction of foul air or liquids by leaking water-pipes during intermissions in the supply.* It is not necessary to go into details of these cases, but it may be stated that at Guildford a sewer was actually traversed by a water-pipe, and at Sheerness 'water mains were often laid in the same trench as tributary sewers.' At Perth river water from near the sewer outflow got into the water main which runs under the Tay.

We must remember that sewer-pipes and water-pipes, however well laid and made, are like ourselves mortal, and liable to accidents and the inevitable results of age. They are perfectly sure to leak sooner or later from some cause or another. If they leak we must reckon upon an interchange of their contents. These pipes are always placed in proximity to each other and *out of sight*, so that if the sewers leak into the water-pipes our first indication of it is an outbreak of disease.

I have a cottage in the Thames valley where the Local Council, by the help of some 130,000*l.* borrowed with the consent and implied approval of the Local Government Board, is and has been busy, by dint of sewerizing and paving all the country roads, in making the way smooth for the speculative builder and site owner, who fill their pockets by building houses with the minimum curtilage allowed by the Local Government Board. The houses are springing up at a rate of twenty-five or thirty to the acre, and at a rent of about eight

shillings a week. I see the water-pipes and sewer-pipes being laid for this mushroom crop of brick and stucco, and in the mornings I hear the traction engine and steam roller rumbling about only a few feet above these pipes, as though their only thought was to make quite sure of cracking them.

I may recall the fact that a few years ago in London the local authorities, by removing every particle of snow and throwing down salt, succeeded in surrounding our water-pipes with a freezing mixture, with the result that no small proportion of them burst; and I may also recall the fact that a deep tunnel caused a dangerous subsidence of the earth above it only a few weeks ago in the City. The only way of minimising the very obvious danger of thus laying water-pipes and sewer-pipes would be to insist that where they go together they shall do so only in subways, where they are open at all times to ready inspection. An alternative would be to insist on maintaining narrow roadways between the backs of new houses, and to keep the sewers at the back and the water-pipes in the front. Whatever plan be adopted, it is evident that these two sets of pipes—afferent and efferent—must come into close proximity somewhere. Nevertheless what I have suggested would lessen this danger.

Next I have to say a few words on the very important subject of the pollution of water at the *periphery*, i.e. *through the taps*.

This mode of pollution has been, I think, most conclusively established.

One of the first persons to call attention to this danger was Dr. Blaxall, in a report on an outbreak of enteric fever at Sherborne. This was followed in a few months by the late Sir George Buchanan's report on

Caius College, which must remain for all time one of the classics in the literature of preventive medicine. Mr. Spear in his report on Mountain Ash, Glamorgan, deals with the same point. I will quote from these three reports, but I think we shall derive most instruction by reversing the order and taking Mr. Spear's first.

1888. *Mountain Ash* (Mr. John Spear).—The 518 cases of this epidemic were chiefly due to the in-suction of foul air (and liquids and solids?) into water-pipes during intermissions of supply. Leakages in the pipes were numerous.

There was some evidence to show that streets supplied with water-pipes having 'dead ends' suffered somewhat more than others. Concerning one of these terminal 'dead end' branches Mr. Spear says, "It would take its full share of the first rush of water (after an intermission), and all impurities would have to be withdrawn through the house taps."

In another place he says, "Given a fever poison present in a water system, it is quite possible that in the dead ends of pipes or at other places where stagnation occurs, or at any given point where escape may take place into the soil, further development of the poison leading to new or more intense infection of the water may occur."

Allusion is made to a dead-end pipe, fifty-three yards long, gradually ascending from a larger main to supply a school, including two closets which were supplied by pipes *direct from the main*. "When the water was turned off at the main, and the tap of one of these closets opened for a moment, suction of air up the pipe was immediately heard." Mr. Spear further adds in a footnote, "Suction into this main was very strong during intermission of service. At such times the house taps

greedily sucked up water placed at their open mouths." It wants only a moment's consideration to see that ascending 'dead ends,' whether in houses or in streets, are converted into powerful aspirators directly pressure within them fails.

In the school above mentioned there were two cases of enteric, and it is possible that specifically infected matter had been aspirated into the mains.

In another part of his report Mr. Spear has this important paragraph:—"Intermission of water-current, however, is not by any means essential to the introduction of foreign matters into water-pipes. Under various physical conditions very powerful in-suction of external matters into a full-flowing water-pipe can take place . . . But the fact of this lateral in-suction into water-pipes 'running full' is not known, as it ought to be, to many of the engineers who undertake the responsible business of laying water mains and other water-pipes."

1873. *Caius College* (Dr. Buchanan).—15 cases, of which 12 occurred in 'Tree Court,' which had been built only a few years and contained all the latest 'sanitary improvements.' Out of 68 residents in Tree Court, 12 (or 19 per cent.) were stricken with fever in the month of November. Tree Court had a water-supply through a branch from the main in the street, which, to use a pathological expression, was an 'end artery,' and, although it supplied a branch to each of the nine staircases of Tree Court, formed no anastomoses with any other water-pipes in the college. This water got fouled by one of two private closets in Tree Court. The manner of the fouling was in this way. The closet which was on the first floor of staircase P was provided with a 'safe,' i.e. a big metal tray surrounding the base of the closet to catch accidental

splashings and drippings. This 'safe' drained into the soil-pipe just beyond the closet-trap, through a small pipe with a trap of its own. The subsidiary trap was fed by what is technically known as a weeping-pipe, a branch of the pipe supplying the closet. This closet supply was direct from the Tree Court main without the intervention of any cistern.

The water-supply to Caius College is 'continuous,' but it is liable to intermissions, and such intermissions are known to have occurred on October 25 and November 1, and probably at other times.

When, with the water turned off, the closet on staircase P was used, the trap of the safe would be emptied and the trap of the closet be left filled more or less with faeces. The weeping-pipe was therefore open to the sewer air coming up the soil-pipe and to the filth in the closet trap. With the pipes of Tree Court empty of water they would be liable to be filled with sewer air. It was further proved that the end of the weeping-pipe was covered with filth, and it is probable that the water system of Tree Court was definitely inoculated with *Bacillus typhosus* in addition to being impregnated with sewer air.

1873. *Sherborne* (Dr. Blaxall).—243 cases. 'Board of Health' water derived from two deep wells. Water-closets supplied direct from the mains. Between December, 1872, and May, 1873, there were 243 cases. "During December, 1872, and January, 1873, the water was frequently shut off from the town at a point near to the reservoir, and the same thing was done every night in February. It is known that when the water was thus shut off there were certain delivery pipes up which there was a rush of air immediately the tap was unscrewed. Now many of the openings of the pipes, as before

described, are situated in the pans of the water-closets. At night, after the closet had been used, the tap would be turned on for the admission of water; none flowing, the tap in many instances would not be turned off again, and thus a direct passage into the water mains would be left open. . . . Thus the system of pipes for the water-supply became the means of ventilating the closet pans; if a trap happened to be broken or out of order it became a means of ventilating the sewers, and if a pan happened to be full of excrement that excrement would be sucked into the water-pipe."

This mode of water pollution is well understood, and we know the importance of maintaining constant pressure in our water service. It seems clear that many of the critics of Maidstone have not been aware of the danger of lessening water pressure at a time when the sewer-pipes must have been highly charged with enteric poison.

How far is the maintenance of constant pressure attainable? It is evident that there *must* arise occasions when the water-pipes *must* be empty. To maintain constant pressure is a counsel of perfection which is unattainable.

The dangers of peripheral pollution, by the induction or diffusion of foul gas or liquid, is so well recognised that all w.c.'s are now supplied through independent cisterns.

There is yet another way in which peripheral pollution of a public water-supply may take place.

The outbreak at Worthing in 1893 was accompanied by an outbreak in the adjoining districts of West Tarring and West Worthing having a different water-supply, and the explanation of this is that Worthing water entered the pipes of the adjoining districts through the ball

hydrants in the street at a time when the pressure in the pipes intermitted.

A few weeks before the close of the last holidays I was staying at Andover, which has a municipal water-supply obtained from a deep chalk well. During one of the last days of September there was a very heavy thunderstorm with torrents of rain. I went out in this storm to one of the lowest points in the town, and there I found what I had found before under similar circumstances, viz. the water bursting up through the street sewer, with the result that the street was flooded with foul water and faecal matter. A few inches below this mess were the water-pipes supplying the district, and I hope they were not cracked, and that the pressure in them was fully maintained until after this impregnating flood had subsided.

I stood at the lowest point to which storm water must gravitate, and here Nature had provided an overflow into a ditch. Some years ago the storm water was taken into the sewer, and a storm overflow from the sewer was taken into the ditch. Nature meant that the sudden storm should cleanse the surface of the ground and also cleanse the ditch, and thus do nothing but good. Man interfered, with the result that, instead of being cleansed, both the street and the ditch were filled with the poisonous purgings of a sewer. I give this as a type of what is common. The craze for taking rain water underground instead of allowing it to run on the surface is as dangerous as it is costly.

The experiences at Sherborne, Mountain Ash, and Caius College seem to point to the conclusion that every public water-supply should *protect its own purity*, by compelling every house to have a cistern of its own as a 'cut-off' between the impurities of the house and the

water in the mains. This necessity is implied by the compulsion which we are now under of having a separate cistern for the water-closets. But water-closets are not the only filthy places. There are water-taps which are theoretically capable of tainting the water-pipes under certain given conditions almost everywhere. Most 'noxious trades' require water. Kitchen sinks are not always sweet; the post-mortem room sink is an uncomfortable thing to think of in connection with peripheral pollution, and bacteriological laboratories fill us with 'horrible imaginings.' Sewer air is everywhere, over street gratings, and at the eaves, and although diluted almost to vanishing point, it makes up by quantity what it may lack in intensity.

In Dr. Thresh's valuable book on 'Water-supplies,' p. 211, I find an allusion to an observation by Sir G. Buchanan at Croydon in 1875, of an instance in which bloody water was drawn from a tap at a house next door to a slaughter-house. This is a fact which is very eloquent in connection with automatic peripheral pollution.

Under existing conditions it appears certain that every common water-supply is to a greater or less extent automatically self-polluting, and it will be interesting to hear what the sanitary officials may have to say on this question of the house-cistern *as a protection to the general supply.*

A dirty house-cistern is doubtless very undesirable for the people in the house. If it is dirty, that is their fault, and it seems unreasonable that the purity of the general supply should be endangered by the filthiness or carelessness of the householder.

That the filthy should 'stew in their own gravy' is reasonable enough, but that the cleanly should be called upon to stew in it is unreasonable.

CHAPTER XVI

RECOMMENDATIONS AS TO WATER-SUPPLY—WHAT TO DO WITH INFECTED MATERIAL—TREATMENT OF INFECTED LINEN—DISPOSAL OF EXCRETA—HISTORICAL.

THE remarks which I have made on public water-supplies seem to show that when we accept a water-supply from a public body, our health to a considerable extent passes out of our own keeping. That is obvious ; and it is also obvious that when the order is given to close a private well, and to accept a public supply, the sanitary authority incurs a very grave responsibility indeed.

The instances I have quoted seem to compel the conclusion that public water-supplies are a cause of the epidemicity of enteric fever. These water-supplies diffuse the poison with a completeness which is almost inconceivable, and further insure that the poison is laid on, as it were, to our very mouths.

The condition of a city with its water-supply polluted by enteric is fearful to contemplate. Not only is the water being drunk, but the inhabitants are washing in it, the dairies and milk cans are being swilled with it, the very pats of 'margarine' are being made up with its help, the oysters are lying in it, the salads and flowers are being sprinkled with it, and the streets are being watered with it. Then when the need

of closet-flushing is at its maximum, and the street sewers are full of enteric poison, comes the order to cut off the water, and it certainly requires great skill to minimise the danger of so doing.

These epidemics show the danger of 'putting too many eggs in one basket,' and they force upon us the necessity of arranging water-supplies with as many independent sub-divisions as may be feasible. They also serve to show the necessity of not permitting the mixing of water derived from different sources. Dairy companies have learnt, by bitter experience, the necessity of keeping the milk supply from different farms absolutely distinct. Water companies must do the same thing.

The great milk companies have voluntarily adopted a system of milk supervision which approaches perfection. The milk is submitted to a daily, almost hourly, examination by skilled experts.

The water companies must do the same thing. Every water company ought to have a laboratory for the chemical and bacteriological examination of the water which it distributes, and there ought to be a proper staff of skilled experts *constantly* at work examining samples taken daily, or even hourly, not only at the source, but at various points in the area of distribution.

Under existing conditions the purity of our water-supplies can only be maintained by vigilance and publicity. The notification of disease is undoubtedly a great protection, but it is clear that *every notification should be forwarded instantly to the water authority and the sewer authority, whose respective inspectors should examine the implicated premises without delay.*

It is evident that repeated chemical and bacterio-

logical examinations of water are of great value, but it is not probable that they are much protection against sudden pollutions occurring after heavy downpours of rain. The mischief is done suddenly, and both the chemist and bacteriologist will possibly be able to register the catastrophe, but not prevent it. It is most important that the public should not be led to expect the impossible, and to imagine that analyses can make a public water-supply secure. The interpretation of analyses is not always easy, but any sudden change in the quality of a water would arouse suspicions.

Of what import is the presence of *Bacillus coli* in a water? This bacillus is known to occur in rabbits and birds. Does it occur in the dung or dead bodies of insects, such as spiders, centipedes, slugs, snails, &c., which are very apt to gain an entrance into wells? Does it occur in fish? This question ought to be answered.

All sources of water not only need to be guarded by chemists and bacteriologists, but they need constant watching by a shrewd practical man. It is not too much to say that all sources of water have their purity endangered by sudden flood and downpours, and water-collection should be as far as possible stopped during such occurrences. A clear water which suddenly becomes turbid must always be dangerous. My shallow well at Andover, which is only five feet deep, and which is absolutely protected from surface or lateral contamination, has once or twice become turbid after exceptionally heavy rains. The reason for this appears to be that so soon as the soil above the ground water gets saturated, the deposit on the bottom of the well is driven upwards by the suddenly increased pressure under which the water rises in the well.

There is very definite safety in having the water sources near at hand and capable of being inspected. By means of the electric light a well of moderate depth can easily be inspected, but it is difficult to know what may have happened in a bore-hole at a depth of 400 or 500 feet.

There are some who are of opinion that the public safety would be enhanced by placing our water-supplies in the hands of public authorities; I am not of this opinion, for the following reasons :

1. Because private authorities can control their servants and get rid of incompetent officers more easily and promptly than public bodies, who are elected to their offices by their servants and the friends of their servants.

2. Because water companies equally with railway companies should be made liable to 'damages' in case of accidents. A successful action for damages against a sanitary authority by, let us say, 10 per cent. of the ratepayers of a town would result in the payment by the plaintiffs of 10 per cent. of the damages awarded them, while the bulk of the remainder would be paid by persons who are blameless and helpless. This is a *reductio ad absurdum*.

3. Because no person should be allowed to control a water company without incurring some degree of personal responsibility. It is the power of borrowing and spending money without personal responsibility that constitutes the dangerous element in our modern local government.

I am very strongly of opinion that water companies should be placed exactly on the same footing as other trading companies, and that every householder should have the right of paying for water by meter if he so

desires. In houses not supplied by meter no waste-pipe should be allowed beneath any supply tap so as to insure that, if the tap be left carelessly turned on, the house must be flooded. This would effectually check waste.

It seems very necessary to check waste of water. Many local authorities are at their wits' end for water, and are calling in the help of wizards. But we have had the comforting assurance that this, at least, is a form of sanitary quackery which the public auditors do not allow to be paid for out of the rates.

Wilful or careless waste of water (as by leaving a tap turned on) should be punished by fine when water is not paid for by meter.

Waste of water often necessitates the severe pumping of wells and other sources, which increases the danger of pollution. Waste must be checked.

There are others who seem to think that we shall attain greater safety by the registration of plumbers. These sanitary scapegoats are, I think, more sinned against than sinning, and are often blamed most undeservedly for the inherent shortcomings of our modern sanitary methods. If, however, plumbers are to be registered, it does seem desirable that they should be divided into two classes, and that we should run no risk of allowing a man to attend to the water service who perhaps carries about him infective matter accidentally picked up in the 'drains.'

THE DISINFECTION OF LINEN

At University College Hospital some years ago this question was submitted to a small committee, of which I was a member, and we advised as follows:

1. That the linen should not be treated with

carbolic acid or corrosive sublimate, because of the fear of coagulating albuminous soilings, and for the same reason that it should not be put at once into boiling water.

2. We advised that a special tank should be provided, and should be filled every day with cold water to which washing soda is added (about two pounds to a hundred gallons); into this tank the soiled linen is taken directly from the wards, and is allowed to soak till the following morning, when the water in the tank is thoroughly boiled for one and a half hours, and after boiling is run off into the sewer. In this way the first stage of the laundry work is accomplished. The effluent water is sterilised, as is also the linen.

The same process can easily be carried out in private on a smaller scale.

DISINFECTION OF STOOLS

We now come to the important question as to what ought to be done with the stools of enteric patients. I have no hesitation in saying that in towns at least they should be *burnt* or boiled, and in all fever hospitals intended for the reception of this class of patients a proper destructor should be provided.

I have very little doubt that if this be accepted as a principle, human ingenuity will soon provide the means.

It is most desirable that, in the interest of the nurses and friends, there should be a minimum of manipulation of enteric faeces. I have my own ideas as to how this end may be accomplished, but I must limit myself to the discussion of principles rather than details. I have very little faith in chemical disinfection. Badly done, this is more likely to preserve than

destroy the poison, and the amount of manipulation which thorough chemical disinfection necessitates is most undesirable.

Of one thing I am convinced, and it is this, that under no circumstances whatever should enteric excreta be mixed with water. We know how insidious this mixture is, and that the danger of it practically increases when dilution has been carried to the extent that the mixture has, to our unaided senses, the characters of potable water. Enteric fever is pre-eminently a water-borne disease. Enteric stools, therefore, must not be mixed with water, because it is the property of water to return to its source.

'All things that are of the earth turn to the earth again,
And all things that are of the waters return into the sea.'

Eccl. xl. 11.

Let me illustrate this by some examples. A stool mixed with water flows to the sewer, and so directly to the sea. One would suppose that a stool so treated was safely disposed of. Not at all; the enteric poison returns to us upon the oyster, and it must be admitted that our habit of mixing enteric stools with water is in a fair way to destroy our oyster industries—the fame of which extends to the extreme limits of our historic record. A very eminent agriculturist has said that our sewage is good for our fisheries. At present we have very conclusive evidence of evil, and no evidence of good of any kind.

Again, an enteric stool mixed with water flows to the sewer, and from the sewer leaks into a deep chalk well, as at Guildford and Worthing, or runs off the surface of a sewage farm into a deep well, as at Beverley, whence it is pumped in a state of extreme subdivision to poison

others. Or the mixture runs to the sewer, and so to the river, passing *en route* through the watercress beds. From the river it is pumped to the consumer of water, and the watercress is sent far and wide, mainly to our operatives in the big towns. The watercress industry, like the oyster industry, is endangered, and we may soon be deprived of this most agreeable vegetable. Or the mixture runs to the sewer or cesspool, and leaking, *under pressure*, worms its way sooner or later to a well or spring, and possibly finds its way to the milk. Or the water leaking from the sewer flows into the leaking water-pipe, and so back to the consumer. Lastly, as at Caius College, the mixture may be sucked directly from the water-closet into the pipe supplying the drinking-water.

Water returns to its source, whether the circuit be long or short.

If any underground receptacle for water or sewage begins to leak, and if the water in such receptacle be constantly renewed, there is no limit to the distance whether laterally or vertically which it may not travel. The danger of a constant drip of water on one spot is proverbial. It is a very serious danger in relation to our water-supply. The deeper it goes, the further it is likely to go. The pressure of a column of water is, roughly speaking, nearly equal to half a pound for each foot of vertical height. The force with which the water returned from the surface into the Caterham well was, at its maximum, about 185 lb. to the square inch.

What has just been said is founded on facts which are familiar to everybody, and which are of almost daily occurrence, and in this discussion it is most essential to keep fact and theory quite distinct. The familiar accidents to which I have just alluded are due entirely

to the fact that enteric stools have been mixed with water.

There can be no doubt but that enteric fever must have existed from all time, and that stools must often have accidentally found their way to a spring or other water source, but I think there is small room to doubt that the great cause of the increase and wide epidemicity of enteric fever in modern times has been the water-closet.

It is now half a century ago (in 1849) that my great master, Sir William Jenner, contributed to this Society a paper which closed the controversy which had been raging for some ten years previously on the identity or non-identity of typhus and typhoid fevers. The distinction between them is so clear that we of to-day can hardly understand the controversy. It has been like a dissolving view; the clearly focussed typhus of 1830 became obscured by new elements, which have gradually entirely occupied the screen, till now we have nothing but the distinct features of enteric, and typhus has vanished.

It seems probable that the main cause of the vanishing of typhus was the repeal of the Corn Laws in 1846, and the better wages and cheaper food which our industrial population has enjoyed in increasing degree.

On the other hand, the rise of enteric was probably due to the invention of the water-closet and the gradual introduction of water-carried sewage. It must be remembered that the year 1849, in which the non-identity of typhus and enteric was settled, was the year in which cholera was raging, the year in which the great fact of water-borne disease was established.

The conditions which gave us the great outburst of cholera in 1849, when the Thames between the bridges was at once our cesspool and our source of water, were

eminently calculated to furnish sufficient enteric fever for the establishment of its identity. If the same conditions had obtained in the days of Heberden or Mead, Sydenham or Morton, the identity of these fevers would have been established one or two centuries before. So glaring a fact could not have escaped these most acute observers.

The sanitary methods of our ancestors were simpler than ours. Water was pumped from a well on the premises, excrement was deposited in a *dry* privy and removed once a year by the nightman, while the slops—trivial in amount as compared with the present day, and containing no specific poisons—ran to a dead well or sump, or flowed in an open channel to the nearest stream. The old-fashioned privy, if kept scrupulously *dry* and if the vault was ventilated, was by no means so offensive as is the cesspool. The smell was *sui generis*. The privy was generally well removed from the house; sometimes was big enough to accommodate three people at once; was furnished with a special seat for children (a most excellent arrangement), and sometimes had a courtyard of its own. There was no sloppiness or putrefaction and not much or any soakage, especially if the vault was ventilated so as to allow of evaporation. When this arrangement was carried out with a fair amount of common sense and with sufficient space the surface-well ran little risk of infection by specific poisons.

Water being unobtainable without the labour of pumping, there was no waste, and allowance being made for evaporation, *the volume of slop-water must always have been less than the volume pumped from the subsoil*. This appears to me to be a not unimportant fact, and it is evident that the soil round the dwelling ran less risk of getting waterlogged and sour than is the case where unlimited water is poured into the premises of thriftless

and careless people, who are incessantly pouring slops into a subsoil from which they are forbidden to pump.

When the water-closet was introduced, and its contents were shot into the previously dry privy, putrefaction resulted. 'Sewer gas' was invented, and the privy began to leak under pressure, to the imminent danger of the well. The privy was, by the use of the water-closet, converted into a cesspool.

As late (I quote Mr. Lewis Angell) as 1815 it was penal to discharge house drainage into sewers. Chief Justice Holt laid it down "that every man should keep his dirt to himself."

The water-closets and the resulting cesspools necessitated first the admission of the *overflow* from cesspools into the sewers, and then about 1848 some 30,000 cesspools were abolished in London, and the houses drained directly into the sewers and so to the Thames. We have had cholera in 1832, 1849, 1854, and 1866; the death-rate from diarrhoea, which in London was .215 in 1838, rose to 1.705 in 1849.

As a direct consequence of the legislation of 1848, every river and every source of water in the country became polluted or in danger of pollution. We then passed a law forbidding the pollution of rivers.

Dr. William Farr fully recognised that the cholera of 1849 and 1854, and the increase of diarrhoea, were due to the water-closet, but he still hoped that the contents of a machine which rids our houses of filth need not necessarily poison our rivers and other sources of water.

I confess I am very pessimistic on this head, as will be gathered from my remarks on the property of water to return to its source; and I feel convinced that unless we are guided by sound principles, all expenditure with

a view to the prevention of enteric fever will be wasted.

In the account of almost every outburst of enteric fever one comes to the inevitable mixture (generally deliberate and intentional, but sometimes accidental) of faeces and water, and in a large majority of such cases we find the water-closet. There are some who seem to think that the abolition of middens and cesspools and their replacement by the underground sewer will abolish enteric. I cannot share any such belief, because it has been shown again and again that the leaking sewer or drain is quite as much a danger as the leaking cesspool, and water leaking from the same spot may (as I have shown) trickle any distance. A drain made of so-called sanitary pipes has a potentiality for leaking at some 1,760 joints in every mile of length.

Every town or village which has underground sewers will certainly, sooner or later, poison its local wells and other sources of water.

Whether or no we are able to obtain pure water depends entirely upon our treatment of putrescible refuse. If this be put beneath the surface of the ground instead of upon it, the danger to every source of water is immense.

APPENDIX

With reference to the Bacterial Treatment of London Sewage, the reader is referred to the summaries of the Reports by Dr. Clowes and Dr. Houston to the London County Council in the 'British Medical Journal' of January 12, 1901, p. 104, and of February 2, 1901, p. 287. Briefly Dr. Clowes, dealing with the general and chemical aspects of the matter, concluded:

- (1) That the effluents from the great mass of London

sewage, clarified by screening, precipitation, and sedimentation, may still lead to serious foulness of the river, containing as they do a large amount of putrescible matter.

(2) That in summer-time, when the flush of water from the upper river is diminished by drought and by the abstraction of larger volumes of the water by the water companies, the condition of portions of the lower river frequently closely approaches that necessary to cause offence.

Fortunately the results of the long experiments carried on so systematically since 1898 indicate that the London sewage may be so far purified by means of contact beds, that a clear, non-putrescible effluent may be obtained far purer than the effluent at present obtained by precipitation and sedimentation. The introduction of such a sewage effluent, clarified and freed from most of the organic matter, into the muddy and brackish waters of the lower Thames may be effected without giving rise to any offence.

On the other hand Dr. Houston, working at the bacteriological aspect, found as the result of a very large number of experiments that the total number of bacteria, the number of spores of aerobic bacteria, the number of liquefying microbes, the numbers of *Bacillus coli* and of spores of *Bacillus enteritidis sporogenes* were not remarkably less in the effluents from the coke beds than in the corresponding samples of crude sewage. For instance, whilst a large number of samples of crude sewage contained on the average 7,357,692 bacteria per c.cm. the average of the corresponding effluents per c.cm. was 4,966,666 (a reduction of 32 per cent.). The average number of the bacteria of the *coli* type in the crude sewage (600,000 per c.cm.) was reduced in the effluents to 400,000 per c.cm. The number of spores of *Bacillus enteritidis sporogenes*, varying from 10 to 1,000 or more per c.cm. in the crude sewage, was found to have undergone very little reduction in the effluents.

Both these bacteria are of special interest, being of excremental origin: the *Bacillus coli* also because of its close association with and resemblance to the *Bacillus typhosus*; the *Bacillus enteritidis sporogenes* because of its virulent character and apparent causal relations to acute diarrhoea. It is argued that if the *B. coli* passes so readily through the contact beds there is nothing to show that the *B. typhosus* will not do the same. Moreover Dr. Houston found that various other species of bacteria, such as the *sewage proteus* and the *B. pyocyanus*, passed freely through the beds. Even streptococci, which are generally known to us as highly virulent

but anything but hardy microbes, he constantly found in the effluents.

In view of these results, it is difficult to differ from Houston's conclusion that "however satisfactory the process may be from the chemical and practical point of view, the effluents from the bacterial beds cannot be reasonably assumed to be more safe in their possible relation to disease than raw sewage slightly diluted, but otherwise unaltered in its bacterial composition."

The far-reaching importance of the above discrepancies between the chemistry and bacteriology of so vital a matter need not be insisted upon. Yet, in many instances, public authorities and private individuals are quite satisfied with the ordinary chemical analysis, the biology of the subject being completely neglected.

CHAPTER XVII

***APPLICATION OF STOOLS TO WELL-TILLED HUMUS—
WATER—DEEP BURIAL—WELLS***

In country places I believe that enteric stools may with reasonable safety be applied to the surface of well-tilled soil. They must not be mixed with antiseptics, and they must on no account be buried deeply. They must be placed only a few inches below the surface, and be lightly covered. *There is no evidence, so far as I am aware, that fæces (enteric or otherwise) treated in this way have ever been productive of harm.* The sooner the ground is planted with cabbage plants the better, and it must be borne in mind that, if the soil is to remain sweet, tillage and cropping are a *sine qua non*, and it is probable that pathogenic microbes succumb in the process. There is no evidence to the contrary. Tillage admits air, and in turning over the ground we have the beneficent effect of sunlight. I have studied somewhat closely for the past eighteen years the result of applying human fæces to a well-tilled humus, and I feel convinced that many who write upon the subject have taken but little pains to inform themselves as to the real facts. The rapidity with which faecal matter disappears in the earth depends upon circumstances, viz. the state of the soil as to tillage, the mass of fæces to be dealt with, and the weather. If the weather be

warm with occasional showers, we find at the end of about three weeks that the whole of the faeces and paper has become humified, and is no longer recognisable by eye or nose. The smell under all circumstances seems to disappear in a few hours. If there be drought or frost the humification is delayed, but, strangely enough, the humification is delayed longest if the weather be continuously wet. Under these circumstances the pores of the soil are closed, and the humus gets sticky and pasty, but the faeces are not and cannot be washed out of the soil. On the top of the soil, water can exert no continuous pressure. What harm are faeces capable of doing when thus applied to the soil? They are not likely to be eaten or inhaled, they cannot be drunk, and nothing short of absolute proof would make me believe that the bacilli can pass downward to the subsoil water, because, in well-tilled soil, the harder it rains the tighter are the faeces locked up, and with them one must suppose the bacilli, so long as they continue to exist. I have never studied microscopically what one may call the progressive fungology of faeces on their road to humification, but I can say this, that on the surface of the ground in the course of a month or so there appears a green algoid growth, looking somewhat like a covering of moss, and then on digging and taking up a handful of earth one may detect little particles riddled with fungi, often reddish and ultimately black. The end is what the gardener calls 'good rich black mould.' Its fertility is unequalled. I must repeat what I have said, that the place of deposit must be *well-tilled humus*. If masses of faeces are dumped down on clay banks sloping to a river they may be washed into the river, and have been washed in many a time. Or they may be driven by torrential rain into deep cracks

in the clay, and this has possibly happened in India and perhaps here also. Again I feel tempted to put forward a hypothetical case. It is this: as long as plants are alive their roots absorb moisture from the soil, but when they die the dead root of a tree or strong-rooted plant like the hop may possibly serve as a drain for the direct conduction of moisture to the subsoil. This is purely hypothetical, and I have no knowledge of any such occurrence. In a properly tilled humus there are no cracks or fissures, and any cracks must inevitably be filled up by the crumbly earth. The power of a well-tilled humus to absorb, transform, and humify organic matter is astounding; and, provided it be tilled and cropped, its power in this way seems steadily to increase, as if 'increase of appetite did grow by what it fed on.'

In my published works ('Essays on Rural Hygiene' and 'The Dwelling-house') will be found details of experiments which show conclusively how great is the purifying power of humus on urine which is slowly filtered through it; and, in short, there is abundant evidence that a well-tilled and well-nourished humus is an absolute protection to our subterranean water-supplies. Further, I believe that, so long as the humus keeps healthy and in a highly productive state, the protection to our water-supplies is proportionate to the thickness and richness of the humus, or, in other words, to the amount of dung applied to it.

Further, I believe, and have supported the statement by arguments in the works referred to, that the best return agriculturally is got by the immediate and daily application of fæces to the land, and that while the fæcal matter is, in agricultural phrase, 'ripening,' one may get a crop of cabbages, and after the cabbages anything

and everything. These statements are founded on an experiment now in its eighteenth year, in which the faeces of about one hundred people have been utilised in the manner indicated on an acre and a quarter of land. Now that the garden is in full bearing it returns me over fifty pounds per acre per annum.

Is it not time that the people of this country were taught that faeces properly used are a source of health, wealth, and beauty? This most important matter holds no place in our National Educational System. There are no municipal gardens for showing how faeces may increase the attractiveness and prosperity of a town, and to demonstrate that the man who resolutely applies faecal matter to its proper use gets an immediate and great reward. The people are silently taught that the only 'decent' (!) way of dealing with faeces is to mix them with water. This filthy mixture, by its putrefaction, fills our courts and alleys with sewer gas; it trickles to our water sources, and the expensive works necessary for attempting to sweeten it and purify it are of such a horrible kind that they are always surrounded by walls which reach higher than the nose and eyes of an ordinary man. I have always contended that there is too much of Hercules and too little of Minerva in our sanitary arrangements. We see the pipes, the engines, the ventilators, the hospitals, and the smoke of the destructor; we hear the incessant thud of steam machinery, and feel the rate collector's hand for ever in our pockets; but we never get a glimpse of the bright side of the matter, the return which Nature inevitably makes to nourish our bodies, gladden our senses, and freshen the air.

In the reports of the Local Government Board inspectors we constantly come across allusions to 'a

polluted soil.' The water-closet has polluted our rivers and the air we breathe; we now begin to hear of polluted soil. The outlook is not pleasant. Sir Richard Thorne, in a recent most interesting address, alludes to experiments carried out by my friend and colleague, Dr. Sidney Martin, which show that the typhoid bacillus will thrive and multiply in a rich soil *previously sterilised*. This is an interesting fact, and I find no difficulty in believing that in the untilled soils, sodden with faecal and other filth, which are found in the close courts of our modern manufacturing towns and in the old quarters of towns which in former ages were walled fortresses, the enteric poison may lurk. There is no more difficulty in believing that the enteric poison will live in sterilised earth than in believing that it will live in gelatine, which has proved a valuable cultivating ground for so many microbes. Acting upon this knowledge, Dr. Ballard showed that cold gelatinous food stored in an unwholesome place might become a cultivating ground for pathogenic organisms, and he published many facts in support of his contention. But it would be quite as unreasonable to condemn jelly as necessarily a dangerous food as it would be to condemn the soil as the natural lurking-place of enteric because under conditions which cannot exist in Nature the enteric microbe may exist in it.

It is necessary to state this because a careless reader of some of the Local Government Board Reports might come to the conclusion that the manuring of the land was a serious danger to the public health. A moment's reflection will convince us that the balance of effects resulting from the dunging of land must be in favour of health, and there is no evidence of evil resulting from farming or gardening operations. Agriculturists

of all grades are the healthiest section of our population. The great cities would be in a most pitiable state if the gardener were not ready to cart away the dung and bring back fresh fruit and vegetables. As the dung of the modern horse bids fair to be cinders, one hopes that a demand will spring up for human faeces, and that the necessary machinery for their decent daily removal will be accomplished.

The soils of cities become polluted because there is a deficiency of air and sunlight and an excess of water. The careless inhabitants can get water by turning a tap. They throw it down the middens, they cast it on the ash heaps, they spill it on the surface. The sub-soil is never relieved of water by pumping, and foul liquids are sure to be soaking into it from cracked drain-pipes. Nothing can purify a filth-sodden soil except tillage, and I much doubt whether an impermeable paving will do any good if there be a chance of drain-pipes leaking beneath it. In some of our filthy industrial styes no sanitary measures short of destruction can possibly do much good, and I fail to see the use of herculean and endless labour in order to secure the survival of the unfittest, unless we give the possibility of wholesome life, which cannot be attained without adequate space.

In these places the soil has become polluted because faecal matter has been allowed to escape the action of the humus, and being mixed with water has been deliberately taken through to the subsoil, out of the reach of natural forces which make for purity, and beyond the possibility of tillage which assists Nature to accomplish her beneficent work in the interest of man.

It is only a well-tilled humus that can satisfactorily deal with excreta. If there be an excess of water—*i.e.*

if the humus is drowned, as in a sewage farm—then any protective action is very problematical.

The following is of interest in this connection :

1894. *High Wycombe* (Dr. S. W. Wheaton).—Town in a long valley between chalk hills. Rapidly increasing population 15,000 (?). Lies on gravel bed, water mainly from shallow wells, partly from waterworks (private company). Town was sewered in 1882. The sewage runs to a twelve-acre sewage farm about a mile from the town, and 'after mixing with a preparation of alumino-ferric oxide' in a sludge pit, its liquid effluent flows directly on to the land. The water-closets of the town bad, and seldom adequately flushed.

Enteric fever had occurred every year since 1886. In one house the admission of a girl with enteric was followed by eight cases, and it was found that (*inter alia*) the soil-pipe of the closet passed over the well and dripped into it.

Again in December, 1894, after a heavy downpour, excreta were washed out of the sewers and into the wells.

1895. *Wycombe Marsh* (Dr. G. S. Buchanan).—Two miles below High Wycombe, and having the sewage farm of High Wycombe at its upper end. Population 700 in 140 houses.

Excreta disposed of partly in privies and pails (the contents being used for gardens), and partly collected by hopper closets, inadequately flushed and run into soak-away cesspools.

In autumn of 1895 twenty-four cases of enteric in nineteen houses situated between two streams—the 'Back-water,' 195 feet above Ordnance datum, and the 'Wye,' 185 feet above Ordnance datum, running parallel to the Back-water and a quarter of a mile from it.

The direction of the flow of ground-water from the Back-water to the Wye and beyond has been traced through the implicated houses.

The Back-water runs through a sewage farm of twelve acres and joins the River Wye. Owing to the fact that the sewers were laid in the waterlogged gravel, necessarily leak, an enormous quantity of sewage is estimated at 2,000,000 gallons per day, is discharged into the farm. The volume of the back-water has doubled after passing through the farm.

In September, 1895, a mill building which had been long untenanted was let, and the mill partly opened was closed. This sudden discharge of streams of Wycombe Marsh, with its subsoil water became impregnated with cholera bacilli. High Wycombe, and the wells of the surrounding villages were more or less affected.

Sir R. Thorne Thorne, in concluding his paper on the case, says that it is interesting, to consider the danger which may devolve on one community as a result of works carried out solely for the benefit of another community." (See also *Cholera in England and Wales*, 185.)

The river Wye flows into the Severn at Gloucester.

N.B.—Two million gallons of sewage is equivalent to seven inches of rainfall over 29,280 acres of land, or 2,555 inches or 21 feet of rain.

Again, the deep burial of faeces does not help their destruction, while the reverse is true. Deep burial in a porous soil increases the danger.

For illustrations of this dangerous method of disposing of infected faeces *deeply*, I would refer you to the following:

report made to the Local Government Board in 1877 by Dr. Ballard, on a prolonged outbreak of enteric at Ascot in 1873-4 5-6. The epidemic was a milk epidemic, but the main difficulty was to account for the specific infection of the dairyman's well.

Dr. Ballard points out that the water-supply of this district is (or was) from wells sunk into a 'running sand' saturated with water, lying immediately below the denser superficial sand.

The excreta of the first case which was imported into the district were buried 'in a hole in the sand' (depth not stated), and further there was a leakage of the water-closet drains into the sand, and Dr. Ballard suggests that the infected material may have reached the dairyman's well by the 'running sand.' He puts this view forward as an hypothesis, and not as a proved fact, but the calmly considered notions of so careful and contemplative an observer are not to be neglected.

This Ascot outbreak of enteric, affecting sixty-nine persons, mainly of the upper and middle classes, appears to have been started by the importation in 1873 of a case belonging to the well-known Marylebone milk epidemic of that year. This latter epidemic was due to a case in Buckinghamshire. Thus we see, in these days of rapid transit, how far infections may travel.

The Marylebone milk epidemic is a good instance of the wrong disposal of infected faeces, and the danger of mixing them with water.

1873. *Marylebone milk epidemic* (Mr. N. Radcliffe).—The cause of this epidemic was traced to a farm in Buckinghamshire. The dairy well had become polluted by long-continued soakage from a piggery, the soakage creeping along the foundations of a wall. Against this wall was the farm 'ash heap,' in which the evacuations

of the farmer (who died of enteric) had been buried, and upon which were cast all the chamber slops of the sick man's room. This filthy mixture drained with the soakage from the piggery into the well.

It is necessary to repeat that if faeces are placed on to humus no antiseptics must be used. Such addition merely prevents the humus from doing its work. The unpopularity of town refuse with farmers is largely due to the antiseptics which have been mixed with it, and which, to borrow a phrase used by an agriculturist, effectually '*kill the dung*'.

I believe that a well, by draining the soil, helps to maintain the purity of the soil; and it is most important to remember that when water for household purposes is pumped from the soil, the slop water returned (allowance being made for evaporation) must always be less than the water pumped. There is, therefore, not much danger of getting the soil round the dwelling waterlogged and unwholesome.

When, on the other hand, an artificial supply is brought into a low-lying district already sodden with filth, and when we give up pumping and proceed to soak the land with our new supply, the purification of such soil becomes a matter of increasing difficulty.

Purification of the soil is attained by tillage, and by allowing the humus to breathe, and not by drowning it.

At my cottage at Isleworth, where I have a quarter of an acre of land, I have my own well, and I feel certain it is a much safer supply than the public supply of the district.

The instances of pollution of private wells by leaking sewers and cesspools are innumerable, but these have been mostly small family epidemics, and there can be

little doubt that on the whole there is safety in private wells—absolute safety if the owner have common sense and will take a little trouble. Private wells in crowded cities must always be dangerous, because of the inevitable leaking sewer.

I ventured to express the opinion in 1892 that a shallow well *properly made*, and in the midst of wholesome surroundings, is a perfectly safe source of water, and it is gratifying to find that this opinion is shared by so eminent an authority as Professor R. Koch. Koch ('Bacteriological Diagnosis of Cholera,' 1894) advocates the raising of water from the subsoil by means of tube wells, which he maintains is a perfectly safe method. He says, "People are now everywhere endeavouring to perfect the supplying of water on a large scale to the highest possible degree, but they should direct their attention to the procuring of water on a small scale also, and seek to limit the spread of cholera to a minimum, so far as it depends on water, by improving wells in the manner I have indicated. Just in this respect a great deal still remains to be done."

In a report made to the Local Government Board in 1893, by Dr. Bruce Low, will be found a table which shows conclusively how large a measure of protection against enteric fever is afforded by the use of wells for the supply of water, even though those wells may be (as in many instances was the case) badly constructed and negligently kept. In the Gainsborough Rural Sanitary District it was found that in forty-one villages, with a population of 13,063, in which the inhabitants drank well-water, there were in four and a half years twenty-five notifications of enteric; whereas in ten neighbouring villages, with a population of 5,693, the inhabitants of which drank Trent water or canal-water, the number

of cases of enteric was 167. In the first group the incidence of enteric was 1·92 per 1,000; in the second group it was 29·3.

It will be gathered that my sanitary faith consists in a firm belief (I do not know a single fact to the contrary) in the protection afforded to our water-supplies by a well-tilled humus. I believe that organic filth of all kinds should be kept upon the surface to nourish the humus, and not be placed beneath it to endanger the wells; and I believe that the great cause of the modern increase of enteric fever has been the water-closet, which has fouled and is still fouling our sources of water. In proportion as we have given up foul water-supplies and have gone further afield the mortality from enteric has lessened; but the sudden outbursts of late years have shown that we have 'scotched the snake, not killed it,' and it is impossible to see any finality or real safety in our sanitary arrangements so long as they are dominated by the idea of putting our filth out of sight below the humus instead of on it.

CHAPTER XVIII

ENTERIC AND OVERCROWDING

THE late Dr. Murchison was of opinion that over-crowding was not an important factor in the causation of enteric fever, and it is quite true that in comparison with typhus or small-pox, or other mainly air-borne contagion, over-crowding plays an insignificant part among the predisposing causes of the disease we are considering.

Nevertheless a reference to the Registrar-General's last Decennial Supplement (supplement to the Fifty-fifth Annual Report, 1895) will show (Table VI., p. 115) that enteric fever was most rife in the more crowded counties. Thus the average death-rate from enteric fever for the whole of England and Wales during the ten years 1881-90 was .20 per 1,000 persons living.

Eleven counties had an enteric death-rate higher than the average, viz. Lancashire, Durham, and Nottingham, .27; North Riding and South Wales, .26; East Riding, .24; Northumberland, .23; West Riding, .22; Cheshire, Monmouth, and Hampshire, .21.

On the other hand, the thirteen counties having the lowest death-rate from enteric were Hereford, .06; Rutland, .08; Bedford, .09; Wilts and Dorset, .10; Somerset, Surrey, and Oxford, .11; Suffolk and Berkshire, .12; Sussex, Huntingdon, and Cumberland, .18.

Broadly speaking, one may say that the enteric death-rate was highest in the manufacturing counties and lowest in the agricultural counties.

Hampshire is the only county which apparently contradicts this statement, so that it may be well to say that the relatively high enteric death-rate in this county is largely due to the big seaport towns, with hospitals (civil, naval, and military) and asylums.

The reason for the relative excess of enteric in the more crowded districts is not far to seek. Not only is the pollution of rivers at its maximum in these counties, but the space round the dwellings is often so restricted that it is impossible to prevent the pollution of the air and soil by excremental matter.

The rural counties are constantly being threatened with various expensive so-called sanitary works. It is important, therefore, to bear in mind that these counties suffer less from enteric than the wealthy urban districts.

In overcrowded places, where people live night and day in what one may call excremental surroundings, there is no escape from contamination. It must be in air, soil, and water; in their food; on their cooking utensils and clothing; in short, everywhere. The only real remedy for this state of things is space round the dwelling. Great schemes of sewerage and water-supply have hitherto merely increased overcrowding. Our 224 millions of local debt has not abolished enteric, while in some places it appears to have increased tuberculosis and diphtheria.

As an instance of enteric in crowded areas, I cull the following from a report by Dr. Bruce Low (1896) on a northern town (Middlesbrough) where enteric is endemic and at times epidemic.

The population of this town has grown in little more than half a century from 5,000 to over 85,000. It lies on a flat near the sea, and is mainly occupied with the coal and iron trades. The area is (excluding fore-shore and tidal water) some 2,700 acres, and in the most crowded parts 10,000 people are congregated on fifty-five acres of land. Dr. Bruce Low says, "The older parts of the town are very closely built; . . . the backs of some of the houses are often shut in by out-buildings, privies, and the like—some [houses] in the old parts of the town are very bad . . . in a dilapidated condition. Houses of this class let for as little as one shilling per week, and afford shelter for a very low class of the population. . . . The employment at the works attracts numbers of persons of a shifting class from a distance. Many of these people are improvident, intemperate, and uncleanly in their habits. . . .

"When a high tide coincides with heavy rainfall, the sewers are unable to contain the accumulated sewage and storm-water. As a consequence there is backing-up and ultimate escape of diluted sewage from street and yard gullies, flooding some streets and the basements of houses."

The *middens* are bricked and not cemented, and "the ground below is often saturated with black and filthy fluid. . . . Occasionally a single midden receives the discharge from as many as six privies. These privies are often a short distance from back doors and back windows, and in numerous instances face the pantry window and are within a few feet of it." In one case the people complained that their windows could not be opened "owing to the abominable odours emitted by the midden. . . . In some cases between the backs of dwellings in parallel streets there is a double row of

midden privies divided by a narrow back passage only four feet wide. . . . The contents of the privy middens are said to be emptied once a fortnight. The wet filth and ashes are mixed and thrown out of the midden into a wheelbarrow, which is emptied out upon the macadamised surface of the front street, and . . . the contents lie in the street for a time while the fluid filth soaks away."

Ash closets provided with pans are also in use. They are emptied on an average twice a week, but the system is greatly misused by the householder. We read that the pans are sometimes dusted inside with carbolic powder. "The pan contents . . . are taken to the dépôt, and after rough articles such as tin cans, matting, and the like have been removed, most of the residue is put into trucks for removal to the rural districts. . . . There is a growing difficulty in getting rid of pan contents.

"The dirty habits of the lower classes [in Middlesbrough] also increase the dangers above indicated. Indeed, it was found that the largest number of enteric fever cases occurred in those parts of the wards occupied by the roughest class of the population, people who took no care of their houses or their persons, and paid very little attention to the state of their food. Some of these persons sleep in unwholesome 'box-bed places,' which resemble cupboards partitioned off from the living-room, and ventilated only by a small aperture, which, when opened, often overlooks the midden a few feet away."

Dr. Bruce Low is inclined to think, as well he may, that the fever in this town is "indigenous fever fostered by unwholesome conditions pertaining to the town itself."

Quite different are the circumstances of the town of Bicester (Dr. Theodore Thomson, 1896), with some 3,000 inhabitants on as many acres of ground, a straggling and old-fashioned town with a stationary population. Most of the houses have good gardens or yards, and there are vault privies, pan-closets, and a few water-closets.

Of the twenty-eight persons first attacked with enteric, twenty-six obtained their water from Crockwell Spring, situated at a point where the town sewer describes a semicircle round it, having the spring in the middle at a distance of some eight feet. This encircling sewer was found to be broken and leaking.

I have brought the closely packed manufacturing town into juxtaposition with a country town for the sake of contrast. In a place like Middlesbrough, where people live surrounded by faecal befoulement, there is no possibility of their condition being made better or worse by water-closets. Nothing can remedy such a state of things short of total destruction and reconstruction. Pending that, however, I think the *daily* removal of excreta should be aimed at, and the local authority should endeavour to acquire a tract of land to give an object lesson in the advantage of a really scientific treatment of excreta.

Dr. Murchison was of opinion that the danger of infection from enteric stools was increased by putrefaction. The permitting of faeces to remain about the house for a week or fortnight, just long enough for putrefaction to attain its maximum, must be terribly hazardous. The model by-laws of the Local Government Board permit privies within six feet of the back-door!

Is no correction for dangerous sanitary negligence

ever to be tried with the individual? A gentleman is placed in the dock for not having his bicycle lamp lighted; is nothing to be done to the man who endangers his neighbour's health by swinish apathy? Many towns correct filthy language by fine; can nothing be tried against filthy acts, which are infinitely more dangerous?

In a small town like Bicester, or in a village, the problem is very different. If the inhabitants would abolish their water-closets, and with them all underground sewers and cesspools, and allow their slop-water and storm-water to run in open channels or filtration gutters, all risk of epidemics of enteric would end. In such a place the great need is properly organised and daily scavenging. Every receptacle for filth—dry closet, ash-bin, slop-gutters—all should be cleaned and swept out *every day*, and the stuff put to its proper use on a spot of public ground where the people may receive an object lesson which should show how much it is to their own interest to be cleanly.

I have been at some pains to lay down what I consider to be the true lines for disposing of enteric excreta, and incidentally for disposing of putrescible filth generally. I am well aware that in big cities, where houses have no curtilage, the convenience of the water-closet will certainly override all other considerations. If any improvement is to take place on the lines I have indicated, such improvement must begin at the outskirts of towns and not in the centre. But the water-closet is practically established by law, and no encouragement is given, even in country places, to the householder who may think as I do, and who may wish, for his own health and profit, to work out his sanitary salvation on his own premises, and

independently of the sanitary authority. No man, of course, must be allowed to endanger the health of his fellow-man; but we all do this when we poke excrement into a sewer without any certain knowledge that it will not leak to our neighbour's water. Individual responsibility in sanitation no longer exists, and it is impossible to fix any responsibility on public bodies.

The long list of epidemics caused by public works must make us think that this system is not working quite satisfactorily. In my published writings I deal with these questions at some length, and I also try to work out some of the details for the attainment of a profitable and safe sanitary independence. Great 'sewage-schemes,' involving large expenditure, are always supported (naturally enough) by the small shopkeepers and the wage-earning classes, who generally control our municipal government.

APPENDIX OF EPIDEMICS

1867. *Guildford* (Dr. George Buchanan).—250 cases due to pollution of a new chalk well supplying part of the town, by quantities of sewage leaking from an old ill-constructed sewer.

Dr. Buchanan alludes to the fact that the conversion of privies into water-closets was a danger, especially in the chalky soil of Guildford.

Sir J. Simon, commenting on the case, says, 'The new well, no one could doubt, was most dangerously situated; in the porous and fissured chalk stratum it was within ten feet of various sewers, one of which indeed was traversed by the iron delivery pipe of the high service,' &c.

1870. *Warwick* (Dr. Buchanan).—'The public water-supply of the town scandalously filthy.'

1878. *Sherborne* (see p. 147).

1870-78.—Mr. Simon gives a list of 147 places infected in these years. In almost all of these reports the words 'polluted water' or their equivalents appear, but the details are seldom given, and no further analysis would prove profitable.

1874. *Lewes* (Dr. Thorne Thorne).—450 cases, due to pollution in the course of and at the periphery of water service caused by intermissions in the supply.

The water main at one spot passed through the centre of one of the public sewers. 'This sewer was in consequence opened up, and when the arch of the culvert was removed at the point where the water main passed through it, a jet of water suddenly shot up into the air. There was a hole in that portion of the water main which was inside the sewer.'

1876. *Tideswell, Derbyshire* (Dr. Thorne).—Outbreak of enteric. 'Spread of disease favoured by conditions in an intermittent water service allowing of suction of foul air into water-pipes.'

1878. *Dewsbury District* (Dr. Thorne).—Population 124,286. Excessive mortality, especially enteric.

'Water-supply for some districts liable to pollution at its sources, and periodically fouled in the delivery mains during intermissions in the service.'

1879. *Okehampton* (Dr. Blaxall).—'Water-supply exposed to pollution by direct communication between water mains and closets.'

1879. *Redhill and Caterham* (see p. 189).

1880. *Enfield* (Dr. Parsons).—Occasional occurrence of enteric. Causes multiple. 'Probable local contamination of intermittent water service by reflux of foul matters from water-closet.'

1880. *Haverfordwest* (Dr. Parsons).—Epidemic of enteric. 'Public water-supply insufficient and liable to contamination both at reservoirs and in course of delivery, by sewer air sucked in during intermissions through leaky flush-valves.'

1880. *West Cowes* (Dr. Ballard).—Enteric fever prevalent. 'Intermittent water-supply liable to pollution in the mains.'

1880. *Sandown* (Dr. Ballard).—'Water-supply from waterworks taken from a stream much polluted in its course by sewage and excrement.'

1880. *Ventnor* (Dr. Ballard).—'Water-supply from waterworks intermittent, and polluted dangerously by free admission of sewer air into reservoir by means of overflow pipe.'

1880. *Llanelli* (Dr. Parsons).—'Water-supply constant and

plentiful, but liable to contamination by filth of population living above intake.'

1880. *Newlyn East, Cornwall* (Dr. Ballard).—'Very scanty supply of water, and mainly from a well with which the village drain freely communicated near its outlet.'

1880. *Totnes* (Dr. Parsons).—'Outbreak apparently due to failure of town water-supply in the exceptionally dry summer, and consequent want of flushing of sewers, drains, and w.c.'s.'

1881. *Blackburn* (Dr. Airy).—288 cases due to fouling of a culvert belonging to the water company by soakage from privies and surface drainage of adjacent cottages at the village of Guide, in which there had been cases of enteric fever.

1881. *Bodmin* (Dr. Parsons).—Severe epidemic. Cause? Water-supply liable to contamination. 'Possibility of reflux of foul matters into public water-supply from closets flushed direct from an intermittent service.'

1882. *Bangor* (Dr. Barry).—548 cases caused by the filter beds being flooded with raw river-water containing excremental matter.

1884. *Sheerness* (Mr. John Spear).—'Water service intermittent, water mains often laid in same trench with tributary sewers, and interchange of contents between house drains and house service-pipes several times discovered.'

1885. *Kiddminster* (Dr. Parsons).—1,200 cases at least. Probably due to in-suctions of impurity during intermissions. The fouling of a deep well by percolation of subsoil water and sewage during a drought also not by any means excluded.

1888. *Hitchin* (Mr. W. H. Power).—'Outbreak of enteric associated with defects of the public waterworks, permitting occasional back-flow of sewage-polluted river-water into the pumping-well.'

1884. *Beverley* (Dr. David Page).—281 cases due to contaminated supply of Beverley Waterworks Company, derived from deep chalk wells (388 feet in all). Company's well and reservoir close to sewage-irrigated field belonging to East Riding County Lunatic Asylum. Sewage from asylum is supposed to have trickled alongside the well shaft.

1885. *Faldingworth* (Dr. Gresswell).—Small outbreak traceable to pump-water polluted by washings from a fever case imported from Newark.

1887. *Margate* (Dr. Page).—Increase of mortality from enteric.

'Water-supply pumped from a well in the chalk, on the outskirts of the borough beside a populous and growing neighbourhood. Water of bad quality and exposed to contamination by soakage of sea-water and from cesspools.'

1888. *Mountain Ash* (see p. 145).

1888. *Buckingham* (Dr. Parsons).—Sudden outbreak of enteric, confined at first to a poor suburb of the town, and specially affecting persons drinking water from a particular 'spout.' The water conduit to this spout exposed to pollution from a leaky drain which had received specifically infected excreta from a previous case of enteric fever.

1889. *Longton, Staffordshire* (Mr. Spear).—155 cases. 'Special incidences of primary invasion in part of the town getting a supply from a particular section of the public water service.'

1889. *Rochester* (Mr. Spear).—Public water-supply from wells in the chalk. 'In very many cases at Strood, and in a few in Rochester, I found water-closets supplied direct from the mains, i.e. without the intervention of any cistern or tank. The danger of in-suction of air, and even of solid matter, into the water-pipes from closet-pans, during temporary discontinuance of water-pressure, is well known to attend this objectionable arrangement.'

1889. *Houghton-le-Spring* (see p. 141).

1890-91. *Tees Valley* (Dr. Barry).—1,468 cases due to public water-supplies taken from the Tees, which was more than ordinarily polluted after a flood.

The water-supplies were owned by the Darlington Corporation and the Middlesbrough Water Board. 'The river is found to be at all times subject to conditions of the gravest fouling, by reason of the fact that human excreta and other filth are knowingly and deliberately conveyed to it.'

1891. *Rotherham, Rawmarsh, and Masborough* (Dr. Theodore Thomson).—211 cases. Caused by the pollution of the High Level Water-Supply of the Rotherham Corporation.

Pollution caused by the washings of manure inclusive of human excrement into the streams contributing to the public supply.

1891-2. *King's Lynn* (Dr. Bruce Low).—226 cases, mainly in February and March 1892, due to fouling of public water-supply by the direct inflow of manurial filth, inclusive of human excreta and typhoid excreta after a sudden thaw and flood.

1890-93. *Newark* (Dr. Bruce Low).—'Out of a total of 297

cases of enteric fever, 78·5 per cent. occurred among that half of the population which habitually consumed water from the public service.'

This water consisted in part of raw unfiltered water from the Trent.

1892-93. *Chester-le-Street* (Dr. Maclean Wilson).—58 cases, mainly occurring in the area of the Consett Water Company, which obtained its water from the Stanley Burn. The burn was more or less fouled with excrement, but three miles above intake was a cottage, draining into the burn, which, in October 1892, contained four cases of enteric.

The Consett water, before distribution, was subjected to sand filtration, but it is pointed out that the sand was obtained from the banks of the polluted River Wear.

1893. *Atherstone Warwick* (Dr. Wheaton).—Outbreak of enteric due to the introduction into the town water mains of polluted water (particulars not given).

1893. *Worthing* (Dr. Theodore Thomson).—1,411 cases in Worthing, West Worthing, and West Tarring. The epidemic in Worthing caused by leakage of a sewer into a heading run from the bottom of a deep chalk well. The epidemic in West Tarring and West Worthing presumably due to infection of the water mains by the entrance of filth from the surface through ball hydrants.

Speaking of the Worthing epidemic, Sir R. Thorne Thorne says, 'Chemistry had all along failed to detect in the water any definite impurity, and it was only in the later stages of the epidemic that the results of bacterioscopic examinations went to furnish conclusive evidence, not only of its being fouled by faecal matter, but of its contamination by the specific material of enteric fever.'

Both waterworks and sewers the property of the Worthing Corporation.

1880. *Newport, Isle of Wight* (Dr. Ballard).—'Water-supply from water-works good and abundant' (*vide* 1894).

1894. *Newport, Isle of Wight, with Parkhurst Barracks Prison* (Dr. Theodore Thomson).—516 cases (population over 10,000). 4·2 per cent. of those drinking 'Newport water' were attacked; 1·7 per cent. of those drinking from private wells.

The water was from chalk wells imperfectly lined, polluted by an adjacent pond, and probably by more distant leaking cesspools,

of which there were many. Water found to contain *Bacillus coli*.

1895. *Rounds, Northants* (Dr. Bruce Low).—129 cases, mainly traceable to two public wells which had been distinctly infected by the rinsings and washings of utensils and linen and stools of enteric patients.

CHAPTER XIX

THE SANITATION OF CAMPS—FLIES AND THE SCIENCE OF SCAVENGING¹

In the recent debate² at the Clinical Society of London on Dr. H. H. Tooth's paper³ on enteric fever in South Africa it was established: (1) that the number of flies in our camps was prodigious; and (2) that these flies were largely a result of the military occupation. There seems also to have been a very general consensus of opinion (8) that flies may convey infection. It becomes therefore of great importance to consider the genesis of flies; and I trust that one who has no claims to be considered a dipterologist may be pardoned for recalling a few common facts.

Flies multiply at a prodigious rate. Given a temperature sufficiently high to hatch the eggs, their numbers are only limited by the amount of food available for them. Linnæus is credited with the saying that three meat-flies, by reason of their rapid multiplication, would consume a dead horse quicker than would a lion, and the fact that certain diptera having some outward resemblance to the honey-bee lay their eggs in the dead carcasses of animals probably led Samson and Virgil to

¹ Reprinted from the *Lancet*, May 18, 1901.

² *Ibid.* March 16, p. 786, and 80, 1901, p. 932.

³ *Ibid.* March 16, 1901, p. 769.

make erroneous statements with regard to the genesis of honey and the manufacture of bees. The breeding of 'gentles' for ground-bait is an industry the practisers of which could probably give much information as to the nicety of choice exercised by flies in selecting material for feeding and egg-laying. According to Packard the house-fly makes selection of horse-dung by preference for ovipositing, and as each female lays about 120 eggs and the cycle of changes from egg to fly is completed in less than three weeks it seems probable that a female fly might have some 25,000,000 descendants in the course of a hot summer. Other varieties of flies multiply, I believe, still more rapidly.

As flies multiply upon, and in, organic refuse of every kind it is obvious that the sooner such refuse is placed where it cannot serve for the feeding and hatching of flies the more likely is the plague of flies to be lessened. The most commonly available method for the bestowal of organic refuse is burial. The egg-laying of flies in dead carcasses commences at the very instant of death, or even before death in the case of enfeebled animals. This fact has been insisted upon by Mégnin in '*La Faune des Cadavres*,' and appears to be true of human beings dying from fever. It is obvious, therefore, that there must be no delay in the burial of organic refuse, and that the burial of animals and excreta is quite as important as the burial of human beings. After a great battle it may not be possible to follow this advice, but nevertheless there can be no harm in insisting that the instant burial of all organic refuse must be the aim of those who are called upon to guard the public health, whether military or civil.

It is impossible to lay down any line of action which shall be the best under all circumstances, and those

who, like myself, have not been through the South African campaign are incompetent to deal with the special circumstances of that campaign. Nevertheless, I am of opinion that much that I have witnessed on Salisbury Plain in connection with camp-scavenging is bad and is not calculated to teach the soldier the right principles of dealing with organic refuse, which is always his most dangerous enemy. The science of scavenging requires to be taught. If the duty of scavenging be left to the ignorant and be controlled by persons who think that necessary details are beneath their notice, then annoyance and disease are the only results possible.

If the scavengings of a camp are to be satisfactorily dealt with the question of their ultimate disposal must be ever present in the mind of the scavenger. The materials collected have to be burnt, to be buried, or to be otherwise dealt with. The mere dumping of refuse in mixed heaps ought certainly to be abandoned, and the contents of the latrines ought to undergo immediate superficial burial at the nearest available spot in order to avoid cartage and spilling. In many cases it should be possible to bury the excreta in the immediate vicinity of the spot where they are dropped. We hear of excreta being buried in trenches ten feet deep, but such a course must mean that they are left exposed to give off odours and to breed flies for many hours before they are under ground and covered up. I have consulted a gravedigger on this question and asked him, 'If you were ordered to dig a grave ten feet deep what breadth and length would be necessary, and what time would you require?' His reply was that (in chalk) the grave would have to be six and a half feet long and three and a half feet wide, and that he would require a day and a half to

complete the work. It is certain that thirty-six or forty-eight hours' delay in the disposal of faeces is most undesirable. I have always advocated the burial of faeces in shallow furrows rather than in deep trenches, and, in this country at least, where alone I have had experience, I am convinced that this is the only reasonable course to pursue. If properly done all offence to eyes or nose is thus ended and the faeces cease to attract either flies or rats. The faeces can be covered continuously as soon as they are dropped, and there is no need of having malodorous open trenches partially filled which are waiting to be completely filled before being covered up.

This burial of faeces must be done methodically and carefully and with every attention to detail. The proceedings must be precisely those of a gardener who is intent upon raising crops. The fact that in war the crops may never be harvested is quite beside the mark and affords no excuse for slovenly procedures which are a danger to health. Nitrification in the soil is the aim equally of the sanitarian and the agriculturist. If a plot of ground fifty yards long and fifty yards wide—slightly more than half an acre—be allotted for the disposal of faeces this should be marked off into, say, sixteen strips, each about eight feet wide and fifty yards long, with a narrow path of about eighteen inches between each strip to allow for watering and cultivation. The line of the furrows must be accurately marked by a cord and reel in the ordinary way, and the digger must move continuously backwards in order to avoid trampling on the freshly dug ground. The making of the furrows should commence at the point furthest from the latrines and it should gradually come nearer to them. The earth removed from the first furrow

should be wheeled down near the latrines, where it will be ultimately wanted to cover the last furrow which is dug. The capacity of the furrow or little trench will depend upon the size of the spade. I find that, working in ordinary garden soil with a spade having a blade nine inches long and seven inches wide (the furrow being consequently nine inches deep and seven inches wide), eight stable-bucketfuls of soil each holding two and a half gallons, or about twenty-two pounds weight of earth, were removed. This amounts to two and a half bushels of soil, weighing 176 pounds, as the measure of the capacity of a trenchlet eight feet long. This trench must be filled with excreta, and great care must be taken that nothing except fæces and paper and the accompanying urine is placed in it. If broken crockery or old tins are accidentally mixed with the excreta they must be removed. The trench being filled with fæces, mark out a digging line at a distance equal to the width of the spade (seven inches) behind the edge of the first trench and then cover the fæces in the first trench by the earth removed in making the second. Owing to the draining away of urine and moisture and their great compressibility it will be found that the excreta undergo a considerable diminution of bulk when tipped into the trench. When the earth of the second trench has been removed and shovelled on to the top of the first trench it will be found that there is a raising of the general level of the ground, and the second trench will be found to have a cross section which is rather triangular than rectangular, owing to the oblique direction of its front wall, which is composed of a sloping bank of friable earth. The surface of the ground must be left crumbly, smooth, and perfectly neat, like a well-prepared garden bed. No particle of fæces or paper

must be left uncovered. There eye or nose, no putrefaction is are beyond the reach of diptera has been no delay in the collection fæces they cannot have been used great extent, so that the soil will be with 'grubs.'

How many men will provide fæces which can be placed in a trench which 176 pounds weight of earth. The answer to this question is given by volume rather than by weight. If fæces and earth require equal weights and if we allow four pounds of fæces for each man—for the sake of convenience the bulk may be neglected—the answer is $176 \times 4 = 704$. If the fæces are four times as bulky as the earth, in any case it seems safe to say, a trench nine inches long, nine inches deep, and seven inches wide would suffice to take the fæces of 100 men. This accords with my experience gained at Andover, where the faecal accumulation in the cottages have been disposed of in trenches indicated for eighteen years, and it has required five years to cover an acre of ground. Men who have not had experience of trenching with fæces are apt to have exact knowledge of the amount of land required. If a trench nine inches long, nine inches deep, and seven inches wide is sufficient to receive the daily quota of excreta from 100 men, then a trench occupying an area of six feet by three feet—say six feet—is enough for a strip of ground fifty yards long. This would serve for a regiment of 1,000 men.

days, and the sixteen strips would serve for 400 days—let us say half an acre per annum per 1,000 men. The actual area necessary will depend to some extent upon the nature of the soil and the care and skill of the scavenger, but in no case can the area required be regarded as a bar to the process—certainly not on the veldt or on Salisbury Plain. It need not be insisted on that a scavenger must be incessantly at work. The excreta should be taken up as soon as dropped and be placed in a covered pail, and the pail when full should be emptied into the furrow and covered up. In this way effluvia are stopped and ovipositing by diptera is rendered impossible. Further, this method of disposing of fæces necessitates no increase of the impediments of an army; no lime or chemicals are needed, and no apparatus beyond a spade and a set of garden tools.

The ground beneath which the fæces are deposited should when the work is done have the appearance of a well-prepared garden bed and it will need little attention until it is covered with herbage of some kind. The only question remaining to be decided is as to what that herbage should be. There can be no camp without water-supply, and in every camp one of the sanitary problems is the disposal of waste water. Some of this waste water should be used in time of drought for laying dust and encouraging fertility in that small area of ground beneath the well-tilled surface of which the fæces are safely bestowed. Then, the higher the temperature the quicker will the ground bring forth green leaves to freshen the air. Whether the crop be grass, cabbage, cereals, onions, mustard and cress, lettuces, spinach, or what not must depend upon circumstances. I think the seeds sown in such ground should always be those of culinary vegetables, which

may prove a real blessing if the camp be long occupied. With a little care in a hot climate one may have a green covering of grass or mustard and cress in a week, which at least will give off oxygen to the air even if it do not serve as an antiscorbutic diet for man and beast—a diet which may just supply that something which is lacking in tinned and salted provisions.

In a temporary camp these methods of excrement disposal are the best on the grounds of immediate hygiene. In places like Salisbury Plain, which are to be used as camping-grounds year after year, latrine gardens are essential, and, if properly managed, should furnish a good many acceptable extras for the canteens. Last year (1900) at Perham, on Salisbury Plain, there was a field of many acres occupied by the scavenging contractor and placed a few hundred yards from the camping-ground. On this were piled heaps of camp refuse, old tins, meat bones, broken victuals, packing materials, and faeces which had been 'dumped' with a view to burning when dry enough. In their recent state these heaps (in which flies were swarming) could be smelt for a quarter of a mile down wind, and when they began to burn the offensive smoke drifted still further and not seldom over the camps themselves. This haphazard method of 'dumping' refuse in pestiferous heaps is not economical, not even from the point of view of the area of ground required, and would be rendered unnecessary by a little care in collection and the judicious use of the spade by men who knew how to turn these despised materials to profitable account. Horsedung in the same way should be neatly stacked in heaps like hotbeds, protected at the sides and covered with earth. In this way the flies would be prevented

from feeding and egg-laying on the dung, large quantities of saladings might be produced, and when the camp was moved this well-rotted material should be applied to the camping-ground with a view to the renovation of the turf. On Salisbury Plain the growth of summer is trodden under foot and there is no systematic renovation in the winter. On turf downs the actual camping-ground should be changed every year and the ground 'top dressed' as soon as the camp breaks up in the autumn. Without careful management and good husbandry these downs will soon be trampled and scuffed into a dusty wilderness. In the same way all the kitchen refuse should (after utilisation to a maximum extent in the stock-pot, &c.) be neatly stacked, protected at the sides, and covered with earth. All organic refuse should be completely protected by soil from the attacks of diptera, and its fertilising properties should be utilised forthwith.

It is sometimes said that we ought to be ready to forgive the house-flies for the annoyance which they cause to us because of their great services as scavengers; but I am rather inclined to take the view that the presence of flies is a reproach to us for not putting organic refuse to its proper use, and that the fly is a robber which has been bred in material which we have deliberately allowed to lie above ground instead of covering it with soil. The scrupulous sweeping up of crumbs and food particles immediately after meals and the instant removal of the remains of food to fly-proof larders need not be insisted upon. I believe that a great advance in domestic hygiene will have been made when the custom is more general of removing dung every day from our stables, piggeries, cattle-sheds, and poultry-runs, and stacking it carefully so as to

prevent the access of diptera, or burying it immediately beneath the surface of well-tilled soil with a view to the production of crops. We pity the horse 'turned out' in a paddock when we see it tormented with 'flies.' Few of us pause to think that if the horsedung had been collected daily and put to more profitable use instead of being allowed to lie about and generate a plague of flies the animal might have been happier and the dung might have been more valuable for fertilising purposes. When flies breed in dung-heaps the larvæ eat the dung and leave the straw. If each fly needs one grain only of sustenance then the 25,000,000 which I have stated as the possible season's progeny of a female house-fly will be capable of robbing a farmer of 25,000,000 grains of fertilising material, which at 7,000 grains to the pound works out at 3,571 pounds, or considerably more than one and a half tons. It is bad economy to have your scavenging done by flies and sad to see your potential wealth make to itself wings and fly away. In my garden at Andover where human excreta have undergone daily superficial burial for about eighteen years there is no excess of flies, and I have come to the conclusion that an essential part of garden management is the daily collection of all garden offal, such as dead leaves, fallen and rotten fruit, &c., and either superficially burying or stacking it so that it shall not serve as a breeding-ground for insects which often prey upon the plums and peaches in the autumn.

In the management of refuse I am no advocate for the use of chemical disinfectants. These are expensive, generally evil-smelling, often poisonous, and lead to an increase of material to be transported. The soil is quite capable, with proper management, of turning all organic refuse into 'soil'—a fact which the experiments of Sir

Seymour Haden and myself have abundantly proved. Our experiments have also shown that from the point of view of the innocuous transformation of organic refuse into 'soil' deep burial is a mistake. This is true alike of dead animals and of excreta. We are happily hearing less of the pollution of the earth and of the growth of microbes and toxins in the soil, and even from the laboratories of bacteriologists we are learning that the soil is our best friend. The use of quicklime in the treatment of excreta is, I believe, quite unnecessary. My experiments in burying small animals tend to show that the quicklime preserves the body and mischievously prevents the beneficent action of the soil. In the management of refuse, there must be no slovenly 'dumping.' What is wanted is proper sorting at the time of collection, great attention to detail, absolute neatness, and an appreciation of the ends to be attained.

In recommending the immediate collection of all organic refuse and its instant covering with earth, I am making no new recommendation. Moses had had experience of a 'plague of flies' in Africa and was no novice in the matter of camp-management. He found it necessary to be most explicit in his directions for the treatment of excreta. These directions are given in Deuteronomy xxiii. 12-14, and I find that in the Revised Version of the English Bible there is an interesting change in the passage. The old version runs thus:

'Thou shalt have a place also without the camp, whither thou shalt go forth abroad:

'And thou shalt have a paddle upon thy weapon; and it shall be, when thou wilt ease thyself [sittest down] abroad, thou shalt dig therewith, and shalt turn back and cover that which cometh from thee:

'For the Lord thy God walketh in the midst of thy

camp, to deliver thee, and to give up thine enemies before thee; therefore shall thy camp be holy: that he see no unclean thing in thee [nakedness of anything], and turn away from thee.'

The new version says (verse 13): 'Thou shalt have a paddle *among* thy weapons,' and as a variant for paddle gives 'shovel' in the margin. The passage, therefore, means that a shovel for burying excreta immediately is a necessary implement in every camp.



CHAPTER XX

AN EXPERIMENT IN SANITATION—COLLECTION OF
RAIN-WATER—DISPOSAL OF SLOP-WATER¹

THIS cottage is represented (*see fig. 6*) not because of any architectural beauty, but because it presents points of interest. It forms the lodge of Gallagher's Copse, which is a mile from Andover Junction, just outside the borough boundary. The borough having recently adopted the Model By-laws of the Local Government Board, it became necessary to trek over the border in order to escape from possible hindrances and prohibitions—an important matter, because the owner is, in the matter of house-building, an experimentalist. The soil is chalk. The foundations were laid out by the aid of a compass, in order to ensure that one angle of the cottage should point due north. This arrangement ensures that there is a possibility of some sunshine upon every wall of the house at every season of the year. The accommodation consists (*see fig. 7*) of a living-room (l), three bedrooms (B, B, B), scullery and wash-house (s), glazed verandah (v, v), earth closet (c), wood-house (w), and rain-water tank (t).

In the house it will be noticed that there is a door front and back, so that the passage can be swept by a thorough draught; that no room communicates directly

¹ Reprinted from *Country Life* of July 6, 1901.



PLAN OF COTTAGE

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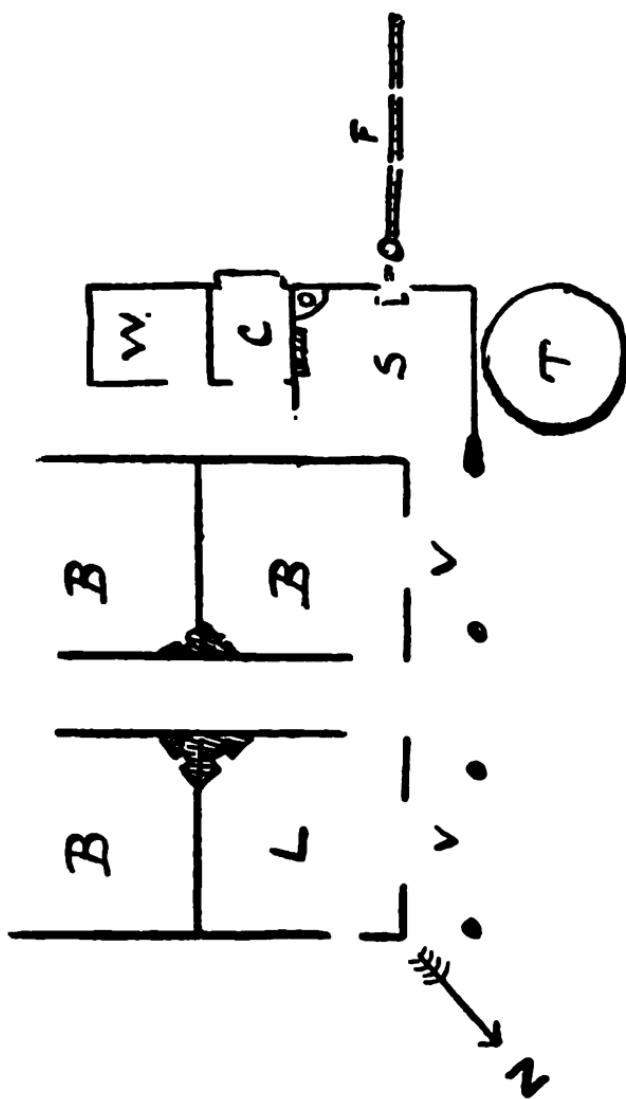
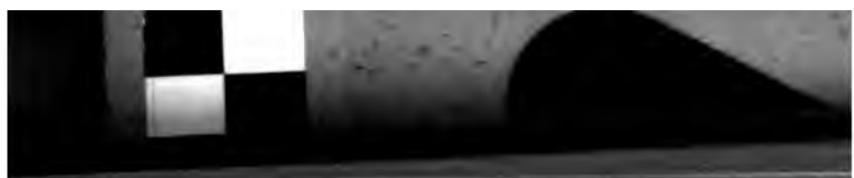


FIG. 7.
Plan of Cottage: L, living-room. B B B, bedrooms. C, scullery. S, earth-closet. W, wood-house. V V, veranda.
T, rain-water tank. F, slop filter and filtration gutter.

with any other room ; and that every room has a fireplace, which, from the point of view of ventilation, is most important. No fireplace is placed against an outside wall. The chimneys do not get chilled, and 'draw' admirably.

This cottage contains what ought to be the minimum accommodation, viz. a living-room, and a bedroom each for parents, boys, and girls. The scullery and wash-house is so placed that, although it can be reached under cover, the smell of cooking and the steam of washing need not invade the dwelling-house. The earth closet is well removed from the rooms, but, nevertheless, can be reached under cover, *via* verandah and wash-house. The walls are built of 'mud,' with rough-cast on the outside. Mud (*i.e.* chalk puddled up with a certain proportion of straw), flints, and timber are the only building materials found in the district. Most of the clay-pits in the immediate vicinity have been long worked out, and there is no stone. Mud is a non-conductor of heat, and is consequently a very warm material. It is said in the district that frozen water-pipes are very uncommon in mud houses. It is very lasting, provided it be kept dry. Mud walling should be begun in March, and should not be carried on after the beginning of September. It is not advisable to hurry your operations. Foundations are necessary for mud walls, and these should be of flint, concrete, brick, or stone. The mud is 15 inches thick, and with rough-cast on the outside and a lining of match-boarding the thickness of the walls is about 17 inches, and the fireplaces being all in the centre and every side exposed to the sun, it is needless to say that the cottage has proved a very snug winter residence. The floors are of concrete, finished in granite cement, and the skirtings are of the same material.



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FIG. 6.—VIEW OF COTTAGE.



PLAN OF COTTAGE

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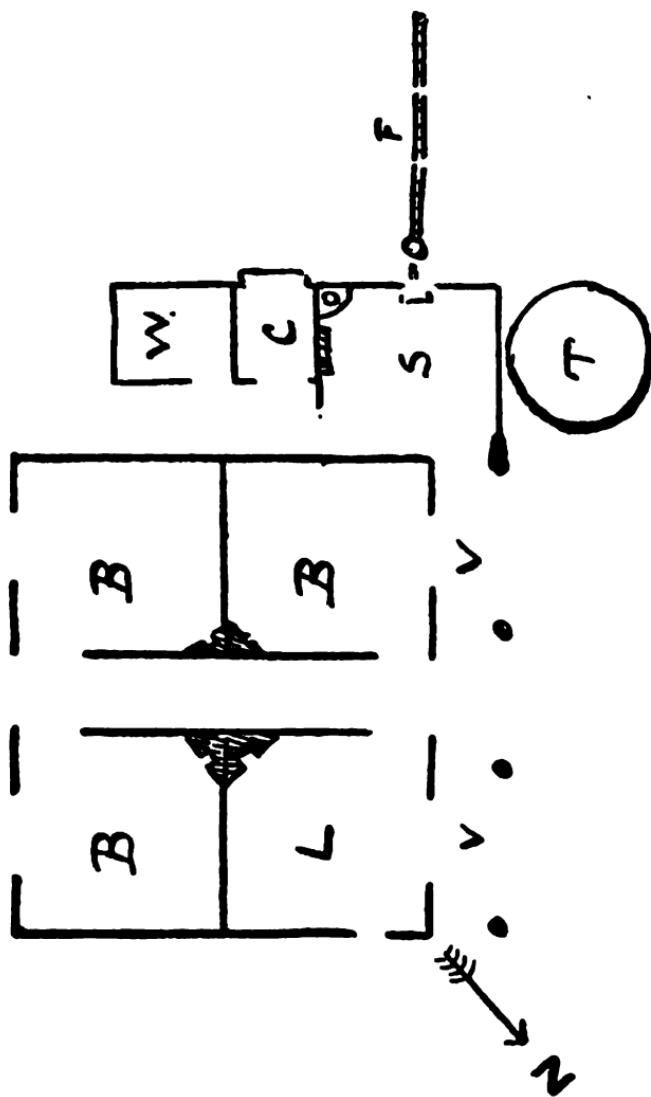


FIG. 7.

Plan of Cottage: L, living-room, B B B, bedrooms, S, cullaecty, C, earth-closet, W, wood-house, V V, verandah, T, rain-water tank. F, stop filter and filtration gutter.

Mud walls are inexpensive. The price paid for the walls of the above cottage was 5s. per perch, *i.e.* a piece of wall 1 foot high, 15 inches thick, and 16½ feet long.

The Model By-laws of the Local Government Board say that the walls of a dwelling-house must be of hard and incombustible material bonded together by good mortar or cement. Now as mud is not hard, contains straw, and is not bonded with anything, it is doubtfully by-legal in districts which have adopted these Model By-laws. In the late fire at Andover it was found that while the thatched roofs blazed, the old mud walls of the cottages withstood the fury of the flames. When the tendency of by-laws is to boycott a local building material and to extinguish a local industry, the *pros* and *cons* ought to be very carefully considered.

An interesting feature of this cottage is the rain-water tank. Although I have a deep well close at hand which supplies an abundance of pure water, I was anxious to ascertain how far rain-water falling on the roof was capable of being utilised for household purposes, notwithstanding that in some districts of England cottages which are dependent upon rain-water only are not permitted. With this end in view, I was careful to provide a very plain, simple roof, without recesses for the lodgment of dirt or nests, and it was this which led me to use slates as a roofing material in preference to the more picturesque tiles which grow moss. My rain-water tank is constructed on the principle of the Venetian cistern. In a city which reached the highest pinnacles of commercial and artistic supremacy on 'rain-water,' one is tolerably sure to get valuable ideas for the collection and storage of that commodity. The Venetian cistern is of large capacity, and is so arranged that all water drawn from the central well has previously passed

through a sand filter. The tank is circular in form, having an internal diameter of 7 feet and a depth of 10 feet. It is divided down the centre by a diaphragm, which is perforated at the bottom by three agricultural drain pipes. Each half of the tank contains 3 feet of filtering material consisting of (from above, down) 1 foot of coarse gravel, 1 foot of fine gravel, and 1 foot of sand. The rain-water which falls from the roof passes through two strainers contained in an ornamental vase, and then, before being pumped, passes down through 1 foot of coarse gravel, 1 foot of fine gravel, and 1 foot of sand, and up through a similar filter, before it can be drawn from the pump. The tank is constructed entirely of cement concrete, and the pump has a copper suction pipe. It was important to avoid the use of lead, iron, or galvanised iron for the storage of rain-water intended for dietetic purposes. It will be noticed that all the water has to be raised by a pump, so that none of it can accidentally run to waste. The drips from the pump are conducted back into the unfiltered half, and should a boy play with the pump, he will merely ensure a double filtration for the water, and will not be able to waste any of it. I believe that half the water which we are supposed to 'use' is merely wasted by carelessness and bad taps. It will be noted that the water tank has been brought to the front of the house, and that an ornamental vase has been used for conducting the water from the roof. Anything amiss with the water tank will be noticed at once. This seems better than a dirty water-butt in an obscure corner. Those who have more money and taste will, I hope, soon outdo me in this direction. I commend the rain-water tank to the attention of architects.

It may be well to dwell for a moment on the powers of this roof as a rain collector. The area of the roof is

(approximately) 1,100 square feet, and if the annual rainfall fluctuate between 24 inches and 30 inches, then the amount of rain falling upon the roof will vary from 2,200 cubic feet to 2,750 cubic feet. If we take a cubic foot as the equivalent of 6½ gallons, then we may say that the amount of rain annually falling on the roof will fluctuate between 13,750 gallons and 17,187 gallons. If we put the average water-supply of the roof at 15,000 gallons a year, or rather more than forty gallons a day, we shall not be far wrong.

Water experts say that in towns we want a supply of forty gallons per head per diem. The dweller in the clean country is content with much less than this, and I feel convinced that ten gallons a day is an extravagant estimate for the daily supply of a perfectly clean peasant who does clothes-washing at home, but has not the power of wasting water.

The storage capacity of the tank is about 1,600 gallons, or forty gallons a day for a drought of six weeks. The water is excellent, odourless and colourless, and altogether very unlike ordinary rain-water.

The water of this cistern was analysed both chemically and bacterioscopically for the Royal Commission on Sewage Disposal on November 14, 1901, and with the following results :

Parts per 100,000 by weight.					
Ammoniacal nitrogen					0·064
Albuminoid "					0·020
Nitrite					0·088
Nitrate					0·086
Oxygen absorbed from permanganate { at once					0·28
at 80° F. { after 4 hours					0·48
After incubation at 80° F. for 6 days { at once					0·28
{ after 4 hours					0·79
Combined chlorine					0·16
Dissolved oxygen (parts per 1,000 by volume)					2·8

'Sample clear but yellow, no sediment, peculiar faint smell rather like soot.'

The above is a typical analysis of rain-water. To the eye and palate it is the best sample of rain-water I have ever seen, and it has been used for all domestic purposes. It should be said that the yellow colour is very slight. Personally I cannot detect any smell, but there is a faint taste of terra-cotta.

Dr. Houston found 25 bacteria per c.c. on gelatine at 20° C., and 7 per c.c. on agar at 87° C. The tests for *Bacillus coli* and *Bacillus enteritidis* sporogenes gave negative results.

These analyses, and those given on pp. 129-130 in connection with my shallow garden well, are full of instruction and show how chemistry and bacteriology are needed to check each other, and how both need to be checked by a knowledge of source and circumstances.

The disposal of slop-water is always an important consideration in cottage management. Usually this means slop-water plus roof-water, but in this cottage the roof water has been provided for. The amount of slops, allowance being made for evaporation in cooking, and washing and drinking, must always be considerably less than the water consumed. Economy in the use of water lessens the slop difficulty.

In this instance the slops are strained and filtered, and allowed to flow away in a 'filtration gutter,' to be presently described. The arrangements are on the south side of the cottage, well exposed to the sun, so as to favour evaporation.

The sink is just beneath the window of the scullery, and the waste-pipe, without trap of any kind, passes through the wall, and terminates in a free end about 18 inches from the wall and 2 feet 6 inches above the

level of the ground. The waste-pipe empties itself into a strainer and filter, which are placed about 15 inches from the cottage wall, so as to avoid the risk of splash or back soakings or accumulations of 'dirt' and insects between the wall and the filter. The strainer is placed on the top of the filter, and the filter discharges its water on to a filtration gutter. This filter is shown in fig. 6 at the extreme right, and is marked with a cross. A longitudinal section of the arrangement is shown in fig. 8.

The strainer consists of a basket with a wisp of straw in it (B). This arrests all but the finest particles, and is the best fat-trap I know—the only one, in fact, which does its work efficiently and without offence. The straw may be changed as often as necessary—every day, once a week, once a month, according to the amount of accumulations, which will largely depend upon the thriftiness and knowledge of the cook. The contents of the strainer may be given to the chickens, put on the manure heap, or burnt. A new handful of straw is then put in and the strainer replaced. The changing of the straw has the advantage of giving a new direction to the water. Any old basket of suitable size which will hold the straw answers the purpose of a strainer. After months of use it will get greasy and rotten, and may then be burnt and be replaced by a new one. From the strainer the slops flow into the filter, which is simply a galvanised iron vessel, with an outlet at the bottom and filled with broken clinker varying in size from peas at the bottom to walnuts at the top. This filter effects a further purification of the slops, and acts partly mechanically and partly by virtue of the growth of bacteria, on the surface of the broken clinker. The filter shown has been specially constructed, and is duplicated (see fig. 9), and the waste-

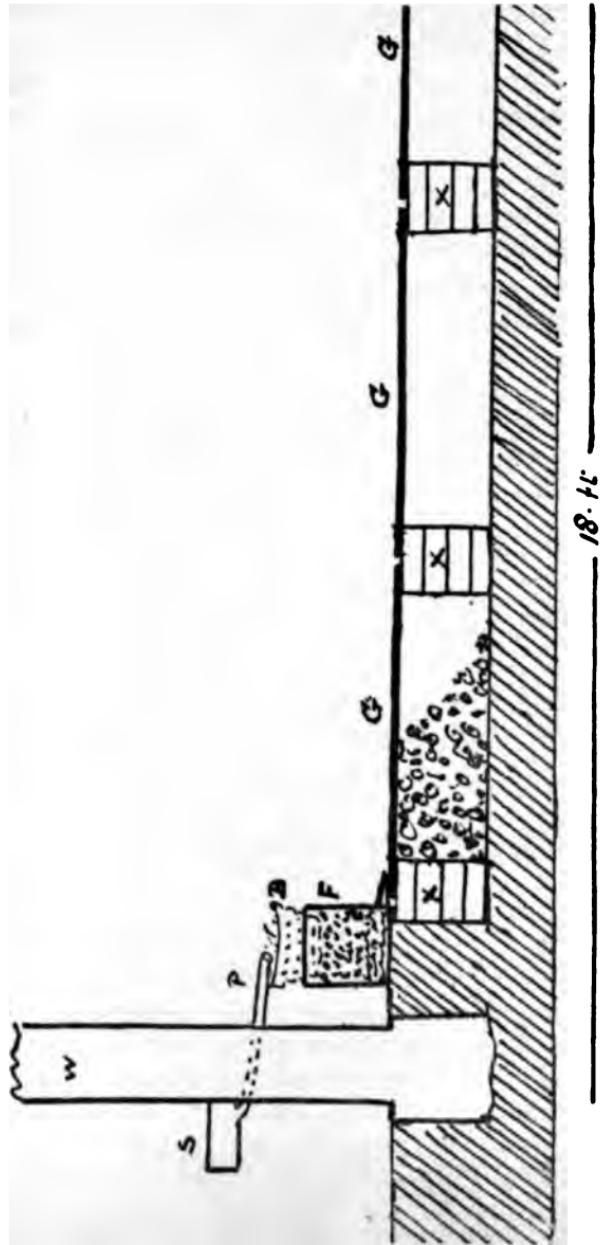


FIG. 8.

B, slink. W, wall of cottage. P, waste-pipe. B, basket containing straw. F, filter. G, cast-iron filtration gutter, supported in trench by (X) columns of bricks on edge.

pipe of the sink is provided with a reversible nozzle so that either half of the filter can be used. For a cottage, however, this is not necessary, and an old galvanised iron bucket with a hole in the bottom will be found to answer every purpose.

The filtration gutter consists of strong cast-iron guttering, perforated with conical holes, having the small ends upwards so that they cannot get jammed (*see fig. 10*). This guttering, which is 9 inches wide and in lengths of

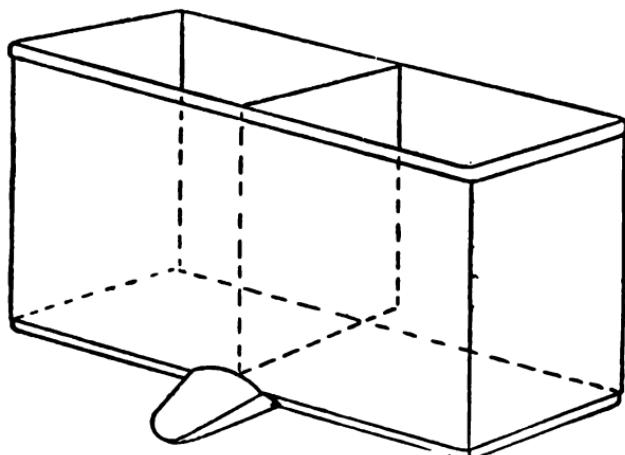
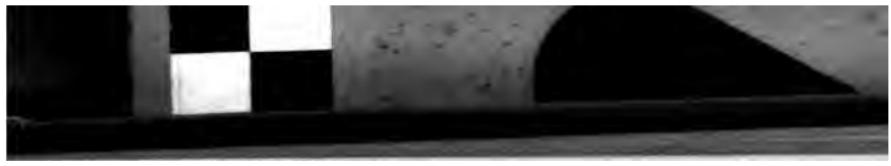


FIG. 9.—DUPLICATED TANK FILTER.

6 feet, is laid upon loose porous rubble or gravel placed in a trench.

A trench 18 inches wide and 18 inches deep was first dug from the filter due south, care being taken that the bottom of the trench should slope away from the cottage, in order that water should not flow back towards the foundations of the building. The lengths of guttering are then laid on a level with the top of the trench, the level being maintained by means of bricks on edge, built



FILTRATION GUTTER

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up without mortar in little columns of four from the bottom of the trench, each column, except the first and last, serving to support the ends of adjacent lengths of

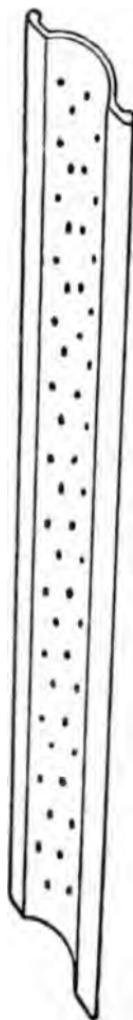


FIG. 10.—*Filtration Gutter.*

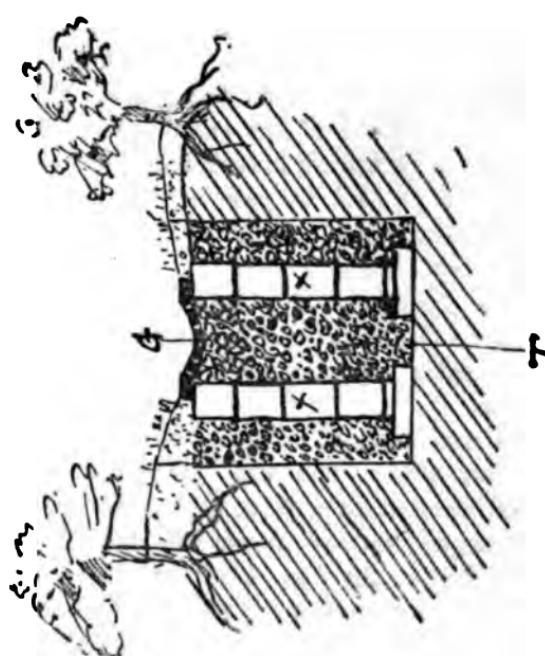


FIG. 11.
G, cast-iron filtration gutter supported on bricks on edge (X).
T, trench 18" x 18" filled with coarse rubble.

guttering. It being ascertained that the level of the guttering is true, with the slightest possible slope downward from the filter, the trench is finally filled with loose rubble of any kind—builders' rubbish, burnt clay, lumps of chalk, gravel, clinker, coke, whatever may be most readily obtained. This arrangement is shown in longitudinal section (fig. 8) and in cross section (fig. 11). Care should be taken that the packing be accurately done at the junctions of the lengths of guttering, in order to give support and firmness to the brick supports. When finished, the filtration gutter looks as though it had been simply laid upon the ground, there being, of course, no indication of the rubble-filled trench beneath it. The iron guttering is sufficiently strong to permit a wheelbarrow or cart to pass over it, and there is no objection to taking the gutter across a path. The sides of the trench should be planted; or the trench may be dug in a shrubbery or plantation. At the cottage in Gallagher's Copse the trench is taken across the garden, and the sides are planted with raspberries and black currants.

The arrangement shown has been in use since September 1900. The straw in the basket has been changed about once a fortnight. The filter has never been changed; we have never seen the slops run further than the end of the first length of guttering, and when the slops are not running the gutter and its neighbourhood looks perfectly dry. There is absolutely no smell, no offence to eye or nose. The length of gutter provided is 24 feet (four lengths), but the water has never been seen to travel more than 6 feet.

Next, as to expense. The guttering has been made for me by Messrs. Tasker, of the Waterloo Iron Works, Andover, and costs 1s. 6d. per foot run, and the special

duplicated slop filter was supplied by the same firm at a cost of 27s. 6d. The total cost, therefore, of draining this cottage was as under :

	£ s. d.
Labour for digging trench, &c.	0 2 6
Basket	0 0 9
Filter	1 7 6
Four lengths of filtration gutter (24 feet in all)	1 16 0
Forty-eight old bricks, clinkers, &c., say	0 1 0
	<hr/>
	£3 7 9

But if an old basket and an old galvanised pail be employed, and if two lengths of guttering be used instead of four, then the above bill will be reduced by 2*l.* 6*s.* 8*d.*, leaving 1*l.* 1*s.* 6*d.* as the total cost for providing drainage for the cottage. Not only does the filtration gutter allow the slop-water to flow away, but it stops back dead leaves, which otherwise would soon choke the porous rubble in the trench.

I may say that I advise that nothing but open guttering be used for slop-water, be it perforated or otherwise. Wherever this putrescible mixture flows in the dark, the faint smell of drains is soon perceptible. Where all is open, those little accidents which proverbially will happen are seen at once.

Finally, the construction of the earth closet demands a few words. Its precise situation and the reasons for it have been previously alluded to. The closet is lighted by a skylight, and air is freely admitted everywhere, both in the closet and beneath the seat—a point of very great importance. The receptacle is spacious, and is in the form of a ‘dry catch,’ as described in ‘Rural Hygiene’ and ‘The Dwelling-house.’ The seat is only 14 inches high. The earth is contained in a bin fed

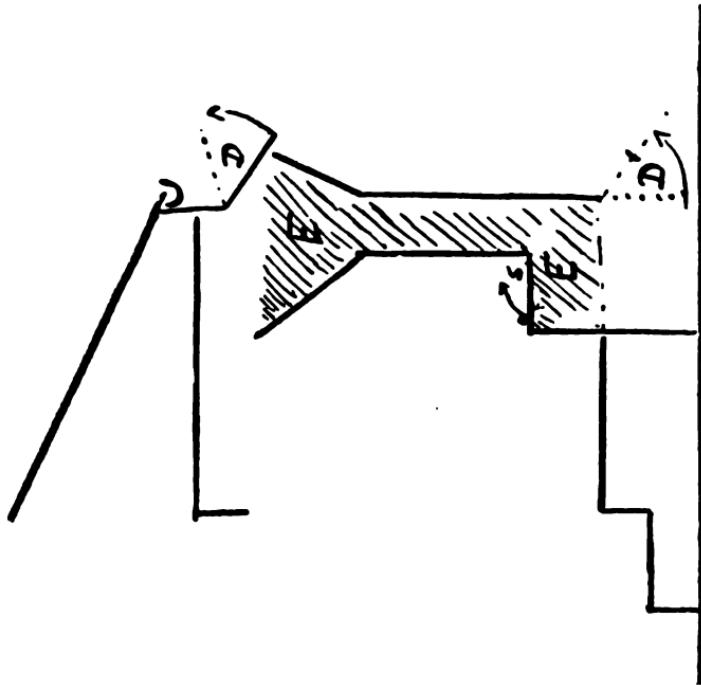


FIG. 18.

Fig. 18, vertical section through A-B. B, earth bin and hopper. S, seat. D, door for filling hopper.
D', door for removing soil.

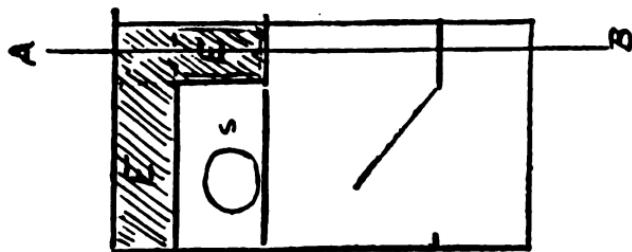


FIG. 12.

Earth Closet.—FIG. 12, plan.
FIG. 18, vertical section.

from a large hopper-reservoir, which holds enough earth for about 1,000 uses of the closet. The earth is added by means of a hand scoop. The earth box is filled, and the soil is removed, from the outside. In the illustration (fig. 6) the lid of the hopper, through which the earth is supplied, is plainly visible. Figs. 12 and 18 show a plan and a vertical section.

CHAPTER XXI

MILK AND ITS RELATION TO HEALTH AND DISEASE¹

I SHALL begin by recalling to the recollections of you all the great work that was done by Dr. Ballard, the medical officer of health for Islington, when in the year 1870 he demonstrated that an epidemic of enteric fever was definitely due to milk. Ballard's work was so important that I hope you will excuse me if I recall the main actual facts with regard to it. They were these:— During a moderate prevalence of enteric fever in Islington in the summer of 1870, Dr. Ballard noted that within a circle of less than a quarter of a mile radius there were 168 cases occurring in sixty-seven houses, and of these twenty-six died. As there were only twenty typhoid deaths registered in the whole of this large parish outside the special area, there was evidently some special cause for the existence of the fever within the special area. The house hygiene, which naturally first of all attracted attention, I think we may dismiss by saying that the houses attacked by the disease were no worse than the others. Then the houses within the limited area where the disease occurred had the same water-supply as the rest of the parish and district. The theory as to the fever which found most credence amongst

¹ An address delivered before the Wimbledon Medical Society, November 8, 1901. Reprinted from the *Clinical Journal* of January 8, 1902.

the inhabitants, and amongst some of the doctors too, was that it was in some way connected with the cutting made for the North London Railway. They talked of 'miasmatic influences,' and they said the soil was polluted. Dr. Ballard was told that the mother of one of the patients had an idea that the epidemic was due to milk, and Ballard frankly admitted that when the suggestion was made to him it appeared ridiculous. But he was a man of singularly open mind, and he went to work with very great patience, and followed up the suggestion of the lady and made, with the willing assistance of the medical practitioners of the district, a house-to-house investigation. He found first of all that there were no fewer than eight cases of enteric fever amongst the family and employees of the dairy. Then he next found that fifty-four of the sixty-two families attacked (87 per cent.) were regular customers of the dairy, and of the twenty-six fatal cases one had come from the country, and the remaining twenty-five were customers of the dairy. This particular dairy supplied 142 out of 2,000 families living in the area, and it was found that seventy of these 142 families had been attacked, and that out of fourteen fatal cases occurring outside the special area five were regular customers of the dairyman in question, and others were chance customers; so that out of the total number of cases of enteric fever at that time in Islington, Ballard undoubtedly showed that a very undue proportion were customers of this dairy. He also found that in 75 per cent. of the families attacked the attacks were multiple—that is, that there were two or three, or even more, patients in one house. And in a particular house where several families lived, and who all used the same foul privy, the only sufferers were an old man and an old woman who drank the suspected

milk. Then Ballard went to the premises of the dairy, and an examination of the dairyman's premises showed that rats had established a communication between the sewers which received the faeces of the house first attacked with enteric fever, and a wooden subterranean water-tank, the water of which was used to swill the milk cans. The conclusion was inevitable.

I am perfectly well aware that everybody in this room is acquainted with this historic instance, but I have chosen nevertheless to give you the details of the case. It was the first time that milk as a serious cause of disease had been really brought into court, and I wish to recall to your recollection how patient was the work of Ballard, how he left not a stone unturned to prove his case. After Ballard's investigation of that Islington epidemic the conveyance of enteric by milk was no longer a 'view' held by this man or by that man, but it was a fact, and you know very well that since Ballard pointed out this fact milk epidemics of enteric fever have been frequently reported. It is due, I think, to the memory of the man who first really demonstrated this fact, that the whole circumstance should be accurately brought before you. It was indeed an epoch-making investigation by a man with a scientific and logical mind. He knew what care was necessary to prove his case, and he definitely proved it.

I would here point out that that epidemic, and others like it, were not due to anything wrong in the cow but were evidently due to bad sanitary arrangements. And I mention this because I am of opinion that there should be no difficulty whatever in any dairy farm, even in the wilds of the country, in obtaining an absolutely pure water-supply. You cannot have a dairy farm unless some part of it be moderately near a stream. There

are always meadows on the dairy farm, and to sink a well, properly made, with securely lined sides, and to dispose of the faeces by dry methods away from the well, is a perfectly easy thing, and there ought not to be any difficulty in getting such wholesome arrangements. It is my opinion, and it is an opinion which may not be shared by all, that on a dairy farm subterranean sewage arrangements which are out of sight, and are liable to be invaded by rats and to leak into wells, ought really, if we are to have any control, not to be allowed. The practice of swilling cowsheds and cow-houses with water and leaving them damp cannot be regarded as wholesome or sanitary in any way. You will find that the best and sweetest smelling cowsheds are those without water laid on, where no swilling is possible, where the cleansing is carried out every day, and the place swept, not swilled.

Now I wish to direct your attention to tubercular disease, and I wish to bring to your notice certain facts which have been brought forward as showing that there is a very definite connection between milk consumption and certain forms of tuberculosis. It is well known that in recent years death from phthisis and death from tuberculous disease have undergone a very notable decrease in this country. The only exception to this rule has been found in deaths from tabes mesenterica among children in the first year of life, and it was concluded by the late Sir Richard Thorne that as children presumably drink proportionately more milk in the first year than in any subsequent year, it might be assumed that the cause of the increased mortality from tabes mesenterica in the first year of life was the bacillus contained in the milk coming from cows with tuberculous udders. This is a very large assumption. An

assumption of that kind cannot be proved without an immense deal of trouble, and I want to bring to your notice the facts as I have read them. In the ten years 1881-1890 there were 8,890,238 children born in England and Wales, and of these children the majority we may suppose were milk drinkers. I wish you to notice, please, that I am dealing with ten years and not with one. Dividing these milk-consuming babies into two classes, we find that whereas 39,194 died of tabes mesenterica, 8,861,144 did not die of tabes mesenterica, so that the odds against a new-born child dying of tabes mesenterica during the period of greatest milk-consuming appear to be 228 to 1. Of the 8,890,238 children born, 1,259,860 died in their first year. That is 142 to every 1,000, so that the odds are 7 to 1 against a new-born child dying in its first year, but if it does die, the odds are 32 to 1 against its dying of tabes. If in a hundred milk-drinking children dying in their first year only three die of tabes, that does not give a high degree of probability that milk and tabes are cause and effect. Although the mortality of children in their first year slightly declined during the decade 1881-1890 (from 149 to 142 per 1,000 births), it is still too high. It may be advisable to consider the chief causes of death of the 1,259,860 children who died in their first year in the ten years with which I am dealing. These were:—Whooping-cough and respiratory diseases, 294,203; nervous diseases (chiefly convulsions), 215,665; diarrhoea, cholera, and digestive disease, 180,201; measles, 25,366; and no fewer than 21,095 died of 'violence.' Tabes mesenterica, as I have mentioned, killed 39,194, phthisis 7,246, and other tuberculous diseases 32,615, the total of the tubercular group being 79,055, and other causes not classified killed

444,275. Thus it appears from these figures that tuberculous diseases caused at the outside about one in sixteen of the deaths of these milk-drinking babies as against about one in eight of the deaths of the entire population at all ages.

Now, before it is possible to conclude that tabes mesenterica is a form of tuberculosis produced by milk-drinking, it would be necessary to demonstrate, by *post-mortem* examination, that so-called tabes is in all cases tubercular. This does not seem in the least degree probable. We know very well that tabes is a loosely used pathological term, and that there are certain things which you cannot put on a death certificate unless you want to fight the parents. To take two things, you cannot put 'starvation,' and you cannot put 'congenital syphilis,' and I take it that tabes is often put down euphemistically because a child has wasted away, so that tabes, although a convenient term, is a term of low pathological value. It is impossible to conclude without a *post-mortem* examination that tabes is tubercular. Tubercular tabes is not diagnosable during life with anything like the certainty that enteric fever is diagnosable. Thus the question arises, out of the 89,149 deaths from tabes mesenterica how many were tubercular? The answer to that is not forthcoming. The next question which would have to be determined is, Are the tuberculous mesenteric glands, supposing them to exist, due to a primary inoculation of the alimentary system? Most pathologists assert—German and English—that primary disease of the alimentary tract is not at all common, and that it is the rule rather than the exception to find caseous bronchial glands or other evidence of tubercle in the body, and if you find caseous bronchial glands or tuberculous lesions in the body, it is quite

impossible to conclude that the condition of the mesenteric glands or the ulceration in the intestines is really primary.

Then supposing you satisfy yourself by *post-mortem* examination that the child had tuberculous disease of the glands, and that that tuberculous disease of the glands was primary, the next question you would have to decide is, To what extent was the child artificially fed? How much cow's milk did it get per diem? And did the milk contain tubercle bacilli? These questions would all have to be answered before you could give probability to the view that tabes, tuberculosis, and milk are related. Ballard found, as others have found, that the existence of enteric fever was not amongst the very poor, but amongst the people who had money enough to buy lots of milk, and I do not think it would be the experience of most of us here present that the existence of tabes or the wasting of children was amongst the well-to-do. We shall find it among the very poor indeed. Having found the bacilli in the milk, you would now have to determine whether or not the bacilli were alive, and did the bacilli come from a cow with a tuberculous udder, or from other sources? Those are all points which you have to decide, so that the question is a very, very difficult one to answer, and it cannot be done by merely holding 'views.' The probability is, as I think I have shown you by the figures quoted, that milk-drinking as a cause of tubercular diseases of the bowels is of no very great importance. Without a complete chain of circumstances, having a tuberculous udder at one end and tuberculous mesenteric glands at the other, it is impossible to establish even a low degree of probability that they are related as cause and effect. In how many of the 89,194

children who died of tabes mesenterica was such a chain established? And without such a chain being established I think the 'view' is really nothing but a 'view,' and a very hazy view too. Even with such a chain established is it possible to exclude other sources of infection in a child born into a world of which one-seventh part of the inhabitants are tubercular? So that you see one is surrounded with sources of fallacy on every side. Then having traced back the tubercle in the mesenteric gland of the dead child to the udder in the cow, can you start from the tubercular udder and say that round that tuberculous udder, or round the dairy, there were scattered in undue numbers cases of tabes mesenterica? I think that is a piece of evidence you cannot get, but it ought to be got. We are dealing with a chronic disease, a disease concerning the incubative period, of which we know nothing, a very insidious disease, and a disease totally different from enteric fever. Ballard showed that the cases of enteric fever could be traced back to the dairy, and he then went to the dairy and showed how the milk was infected, and how it spread the disease. He explained the matter from both ends. It is perhaps not possible to bring forward similar evidence in the case of tabes mesenterica. We ought, however, unless we can bring forward evidence of this kind, to maintain a discreet reticence, because it is no good 'quarrelling with our bread and butter,' nor with our milk unless we have some real solid grounds to go upon. If, as seems probable, it be true that cow's milk as a cause of tuberculosis holds an insignificant position, I cannot think it is wise to adopt an alarmist attitude on the question.

Now we will go to the death-rate from tabes mesenterica, and I find that the rate in 1881-90 for the whole

population—I cannot get it for children under one year of age—was '28 per thousand. Now certain counties were above the average for England and Wales as a whole, and these counties were Durham, Northumberland, Nottingham, London, Lancashire, the North Riding of Yorkshire, Staffordshire, and Worcestershire—all of them, you will perceive, manufacturing counties. When we come to the dairying counties we find that the rates for tabes are lower, and lowest of all in Dorsetshire, where the rate was only '11 per thousand, as against '46 in Durham, where the rate was highest; that is to say, there were more than four times as many deaths from tabes in Durham as in Dorsetshire. If you go through the agricultural and dairying counties you will find the same low figures; thus, Dorsetshire '11 per thousand, Rutland '12, Westmoreland '13, Berkshire, Oxfordshire, Herefordshire, and Huntingdonshire '14, Somersetshire '15, Hertfordshire '15, Shropshire '15, Sussex and North Wales '18, Northampton '18, Devonshire, Gloucestershire, and Bedfordshire '19. It is an interesting fact that in the dairy counties the death-rate from tabes mesenterica is low and in the towns it is high. In short, proximity to the cow and possible facilities for obtaining raw milk do not seem to have had any untoward effect upon the tabes death-rate.

Next I will endeavour to show what is the incidence of phthisis in the milk trades. Dr. Tatham gives in the supplement to the 55th Report the death-rate of occupied males, or, rather, the mortality figures of occupied males between the ages of twenty-five and sixty-five from certain causes. I have only taken out some causes; I do not want to weary you with unnecessary details. The mortality figure from all causes in all males he takes as a thousand, and the mortality figure of occupied males



is rather less, because all males includes diseased males as well as healthy ones, and the ones who are occupied live longer, of course. Now, the mortality figure of all occupied males from all causes, taking the mortality of all males as 1,000, is calculated by Dr. Tatham as 958 ; from alcoholism it is 18 ; from phthisis, 185 ; from bronchitis, 88 ; from Bright's disease, 27. The group of persons who have the highest mortality of any are the inn and hotel servants in London. Their mortality figure from all causes is 1,971, that is, more than double the mortality figure of all occupied males ; from alcoholism, 189, as against 18 ; from phthisis, 607, as against 185 ; from bronchitis, 158, as against 88 ; from Bright's disease, 60, as against 27. These figures bring out very well what Professor Brouardel insisted on at the late Congress on Tuberculosis in London, that alcoholism is undoubtedly a great cause of death from tuberculosis, and the high mortality figure of 607 amongst hotel servants from consumption is a very interesting point. Now we come to the group that is most important to us, that is to say, the milk-sellers. The mortality figure of milk-sellers from all causes is 1,061, which is a little above that of all occupied males. I may say that the mortality figure of all shopkeepers is above that of all occupied males. In milk-sellers the figure for alcoholism is 16, for phthisis 166, that is, below the average for all occupied males. I think that is very important, that these people who are always about with milk have a mortality figure from phthisis less than that of all occupied males. All occupied males give 185, but the milk-sellers 166. Next I take the butcher. His mortality figure is 1,096. From alcoholism, 35 ; phthisis, 195 ; bronchitis, 79 ; and Bright's disease, 35. Lastly comes the farm labourer. His mortality figure

is very low. It is 692, and the deaths from phthisis only 115, and the farm-labourer is constantly engaged, of course, in milking cows, possibly with tuberculous udders, and probably manuring the land with the dung that is voided from the tuberculous intestines of cows. Taking the mortality figures for various trades from phthisis, we have : Printers, 826 ; bookbinders, 825 ; hatters, 801 ; tobacconists, 280 ; tailors, 271 ; drapers, 260 ; shoemakers, 256 ; butchers, 195 ; milk-sellers and dairymen, 166 ; fishmongers, 160 ; greengrocers, 154 ; grocers, 181 ; gardeners, 106 ; physicians (who are always, if I may say so, in touch with tuberculous sputum, but they are driving in the open air and are well fed), 105 ; clergymen, 67. It is to be noted that in the above list those who are habitually brought presumably into close contact with the *Bacillus tuberculosis*, such as the physician who tends the patient, the clergyman who visits him and buries him, the dairyman who sells tuberculous milk and butter, the butcher who deals in the meat of tuberculous oxen, and the agriculturist who tends the tuberculous cows and spreads their tuberculous dung upon the soil, show no excessive tendency to phthisis. I will remind you these are figures culled from the tables of the Registrar-General in his supplement, and I think they are not to be lost sight of in examining this question.

Then, again, what has been our practice in this matter ? Do we regard tabes in a child as due to milk or due to want of milk ? It is a very great question indeed. At University College, where we have not too much money, we have a large Samaritan Fund, and we used to spend a good deal of that Samaritan Fund in giving away new milk to children that wanted it. We gave the child with tabes cod-liver oil, of course, but an

order for a pint of new milk every day had remarkable effects, and the way those children thrived on it, and the way they got well, was truly wonderful. My experience at University College, and also at the Royal Infirmary for Women and Children, in the Waterloo Road, was exactly the same. It is a most important question. Now, I do not think that this question can be settled by laboratory experiments only, and I may say that, whatever the answer may be to the question which is to be tried again in the laboratories as to the exact relationship between bovine tuberculosis and human tuberculosis, we must not set aside the practical, the clinical, and the epidemiological aspects of the question.

I have asked again and again for epidemiological or clinical facts which go to show that milk from a particular dairy has caused an undue amount of tuberculosis in its milk consumers. Such evidence is wanting. Perhaps that is due to the circumstances of the case and the nature of the disease. Be that as it may, until such evidence is forthcoming we ought to be very careful how we move. We must have both science and practice going hand in hand. In Ballard's case the discovery of the *Bacillus entericus* merely strengthened the attitude he had taken up. So with regard to Lister's great work; Lister took up what Pasteur had begun, and showed that Pasteur's views were facts, and facts capable of practical application. Now can you piece together milk and *tabes mesenterica*, and show that they are cause and effect?

It is too much the fashion at the present day to take up a bacillus and multiply it (as these things do multiply on cultivating media), and imagine all kinds of mischief. That is not science. That has been done a good deal of late years. For instance, people have said all bacilli

are so dangerous that the only rational thing to do is to burn the dead body. Well, that is a matter that has interested me, and I have looked about for evidence of definite mischief having arisen from cemeteries. There is not any. I do not say that some illness may not have been caused occasionally, but on searching the Local Government Board Reports I get no such evidence. My own belief is that although cemeteries may be harmful, yet they do a great deal more good than harm, because they necessitate open spaces and growing of trees, which freshen the air, and they keep the population a little apart from each other. Our great object nowadays is to prevent undue density of population, and anything which prevents overcrowding and spreads the people ought to be very welcome. Then again people have said, and not very long ago either, that the typhoid bacillus grew in the earth. Well, it seems very natural that it should, but it does not, and there has never been a case in which a definite typhoid epidemic has been spread by the earth. They said this happened at Maidstone, but of course it did not. You have only to read the evidence carefully to find that such a statement is a perfectly gratuitous assertion. Six bacteriologists were at work at Maidstone, and they never discovered the typhoid bacillus in the soil. (See p. 58.)

If I have not touched upon the burning question of the relation of bovine tuberculosis to human tuberculosis, it is because I am not qualified to speak on the subject ; I am not a bacteriologist, and it is purely a bacteriological question. But even supposing that, by dint of great ingenuity and perseverance, you can make a bovine tubercle bacillus grow in a human subject, we should still want to know the meaning of it, and we must remember that just now people are very busy

taking a disease from calves and inoculating it into human beings *to do them good*. Lord Lister said at the Congress on Tuberculosis that it had been very difficult to prove that vaccinia and variola were the same disease. Even if the possibility of the transmission of bovine tuberculosis to the human subject be admitted, you have still got the other question to answer, whether such transmission works mischief to the human race. I feel that we must keep to the practical and clinical side, and ask ourselves whether we in our daily experience have definitely seen harm from drinking good milk—I am not speaking of sour milk or bad milk. I think it is an important matter, because we must be careful in this country not to get under the influence of doctrinaires, of people who start a particular view, and then run it for all it is worth and write it up. I have brought figures forward which go to prove that the whole thing needs a very careful consideration, and that evidence is wanting from many sides.

The chemist can tell us very little indeed about food. Whether it contains so much nitrogen or so much carbon, &c. is not of much interest. There is a great deal in food besides its chemical composition, and I would remind you that we know nothing about the chemical cause of scurvy. All chemical theories we are inclined to set aside altogether, and we go back and say it is the want of fresh food—fresh vegetables and fresh meat. If we use these with really fresh milk from the cow, or from the breast, scurvy tends to disappear. When we are told that sterilised milk is as good as new milk for the child, because animals maintain their weight on it, I think that is a specimen of science run mad. Children fed upon artificial food maintain their weight, but though they may be fat, rosy, and plump,

they may soon be down with rich
that the mere fact that the child
not enough. How about its vulnera-
various kinds? Remember that
over nine months of age who are
mixed diet, the question of whether
fresh is not possibly of much im-
matter to me whether my milk is
consume many pints in a month
mixed diet of many other things.
whether they get the right or the
important, and we have to remem-
find that out in a few months of
several generations, but neverthe-
important, and all the more so be-
in population of our towns and
are getting further and further re-
supply and from their food-supply
practically nothing about our food
know less and less about them, even
foods are wonderfully and curiously
remember that sterilised milk is
dairyman; sterilised milk will not
bottles it, but is the bottled fluid to
I doubt it very much indeed. The
to meat, which nowadays is often
Is such meat the same as fresh
more and more preserved foods,
further away from the really fric-
great deal more tuberculosis in
country. I am inclined to think
dren of the cities will be impro-
much new milk as you can get them.

CHAPTER XXII

SOME DIETETIC PROBLEMS¹

CHARLES LAMB in one of the most charming of his essays makes complaint of the man whose utterances are of too positive a kind. The West Kent Medico-Chirurgical Society will have no cause to pass a similar criticism on the Purvis Orator of this evening.

It is mainly because the 'twilight of dubiety' has fallen upon me in regard to some dietetic problems, that I have selected that subject for my discourse. Some of the utterances on these questions which are found in text-books, and which appeal to the wayfarer from the hoardings in the streets, where the Fat Bulls of Bashan compass us in upon every side, are to my thinking of too positive a kind.

The change which has taken place in the dietary of the British in the last two or three centuries is prodigious. The diet of our ancestors consisted mainly of meat (including fish and poultry) and bread and beer and wine and other fermented drinks made from honey. Even in the dietaries of kings and nobles fresh vegetables are seldom mentioned. Sugar and spices and dried fruits were luxuries, brought from 'the Indies' for the tables of the rich, and except for occasional 'pippins and

¹ Being the Purvis Oration, delivered to the West Kent Medico-Chirurgical Society, December 7, 1900.

cheese,' fresh fruits were barely represented on the dinner table. In the bills of fare of William of Orange, I find mention of asparagus as an item served occasionally for His Majesty's dessert.

It is difficult for us to conceive a dietary of which tea, coffee, cocoa, sugar, and potatoes formed no part, and into which fresh fruit and vegetables only occasionally entered. How the poor, living on bacon and salt meat, dried fish, bread and cheese, came through a severe winter, we can scarcely understand ; nor can we wonder if occasionally they were tempted to go 'in search of conies,' or to cast covetous eyes on the fat deer in his lordship's park. It is scarcely open to doubt that the high mortality of these times and the frequent deaths from 'the purples,' the 'bloody flux,' and allied diseases which suggest a scorbutic habit of body, was due to the comparative absence of fresh meat and vegetables from the dietaries.

Fresh bread, good cheese, sound beer and honey have each of them, probably, some antiscorbutic power ; but if the bread be stale or sour, the beer 'turned,' and the cheese rancid or mouldy, so that they create loathing instead of appetite, the peasant's condition becomes critical.

The gradual improvement in agriculture, especially the systematic use of 'roots' such as turnips and mangolds for the winter sustenance of sheep and cattle, has made the procuring of fresh meat in the winter an easier matter. Concurrently the supply of human food has been improved by the horticulturists, who have made potatoes, carrots, turnips, ground artichokes, celery, spinach, onions, leeks, beet, and the whole tribe of cabbages available for our winter use.

More important still has been the effect of free trade

and rapid transit. The best of everything the world supplies is to be had in our markets at a price against which the home producer finds it difficult to compete. Bananas are almost as cheap as turnips; oranges may sometimes be bought at little more than a farthing each; while grapes and pine-apples have long ceased to be the exclusive luxuries of the wealthy. Imported animal food is equally plentiful, and it is as true to-day as it was in the days of Erasmus, that the masses of our population fare equally as well as the monarch.

There is every reason to think that the improved nutrition of the people has been the chief factor in that improvement in the public health which has been witnessed in the second half of the nineteenth century. There is no excuse now for that taint of scurvy which made the populations of the sixteenth and seventeenth centuries so vulnerable to disease; and the disappearance from among us of spotted fever, typhus, and the purples is probably due to this cause. That immunity to zymotics is largely proportioned to the healthy nutrition of the people is an assertion which may, I think, be safely accepted.

There are one or two facts which tend rather to check our optimism, and to suggest a questioning as to whether the suppression of epidemic disease tends to enhance the vigour of a race.

We are now confronted with the fact that the diminution of our birth-rate is tending to rather more than counterbalance the diminution of the death-rate, and that an ever-increasing proportion of the population has to be partially or wholly maintained at the public expense. We may hesitate to call these assisted persons 'paupers,' but the fact remains.

The infants in our great cities are as delicate as

ever, and in hot seasons succumb to dietetic disease in numbers which do not diminish. The pale and rickety are apparently as plentiful as they were twenty years ago. Our women, especially among the rich, are neglecting the sacred privilege of suckling, and are content to leave their offspring to the tender mercies of advertising tradesmen, who compare badly with the she-wolf that nurtured Romulus and Remus.

We have long recognised rickets as a dietetic disease, and in addition to rickets we have in recent years been taught by Barlow and Cheadle that very definite scurvy is not uncommon among infants who are artificially fed.

The increasing tendency to dental caries has been attributed, and probably with justice, to deficiencies in diet, and the ever-present dyspepsia, the scourge of all ages and both sexes, betokens a want of vigour for which dietetic errors are probably partly answerable. Again, while I am ready to give every credit to our improved powers of diagnosis, and to the greatly lessened dangers which anaesthetics and antiseptics have brought to abdominal operations, I cannot but feel that purulent collections within the abdomen are relatively more frequent than they used to be, and it seems certain that the human intestine is at least as vulnerable now to the infection of enteric or dysentery as it was in former days. These are questions which one cannot dissociate from dietetics and nutrition. Nor must we refuse to consider in like relation our increased and steadily increasing susceptibility to malignant disease.

What we arbitrarily speak of as our advancing civilisation has brought the important question of the safe and effective 'hand-feeding' of infants very much to the front, and very laudable efforts have been made, *first*, to discover the proportions in milks of a

few complex ingredients which the chemist is able to isolate and identify ; and *secondly*, by artificial means, and often by the addition of materials which are not found in natural milks, to make the milk of the lower animals similar in composition to the milk of women.

But this is something more than a mere question of chemistry. It is a question of biological action ; and it seems to me certain that, in spite of infinite pains and skill, milk *in mamma* must always be something very different from milk *in vitro*.

Milk in the breast is a part of the living mother, just as the blood is, and like the blood it begins to undergo physical changes the instant it is drawn. The temperature falls, the fatty particles begin to separate, and if it be whipped or churned there is formed, by a process still imperfectly understood, that coagulum which is conventionally known as butter.

In a very little time, proportionate to the temperature of the air and the purity of its surroundings, milk turns sour or putrid and becomes unfit for human food, and is often dangerously polluted by the filthy ways, the carelessness, or the dishonesty of those through whose hands it passes on the way to the consumer.

To the suckling at its mother's breast, attached like a bud to the parent stock, the milk flows from the living cells of the mammary gland to the living stomach of the child without risk of contamination, without loss of temperature, without exposure to the air, without any separation of its constituent parts, without, in short, any of those physical changes which milk undergoes *in vitro*, and which make it progressively less digestible. It is probable that the composition of human milk varies, in accordance with season and

diet, as much as does the milk of cows, but this is a matter of small importance in comparison with the physical difference between the milk which comes direct from the mamma and the half-churned fluid which is sucked from a bottle through a rancid bit of indiarubber tubing.

I am inclined to the belief that milk becomes less and less suited for the nutrition of an infant in direct proportion to its remoteness in point of time from the mammary gland.

It is difficult very often to form a judgment on the effects produced by drugs or foods, because of the impossibility of getting away from the *post hoc* fallacy.

I find, however, that there is an absolute consensus of opinion among my obstetrical friends that children which are nursed at the breast do better than those which are hand-fed. My colleague, Dr. Herbert Spencer, in particular speaks most positively on that point. I am able to bring before you one case, which seems very full of instruction.

A medical friend of mine has had three children, and he has been good enough to place in my hands a record of the weights of these children for the first eleven weeks following birth.

The interest of the record consists in the fact that of these three children two were hand-fed, while the third has been nursed by its mother. They are all three boys, born in the same house, and in the midst of comfort and good hygiene. One experiment is not much, but the circumstances of this one seem to give it a special value. The father says 'all were splendid chaps at birth,' a statement which, with regard to the two first, I am able to corroborate.

—	¹ Hand-fed	² Hand-fed	³ Nursed
Weight at birth . . .	8 lbs. 10½ oz. (188·5 oz.)	9 lbs. 1 oz. (145 oz.)	9 lbs. (144 oz.)
Weight at end of first fortnight . . .	127·5 oz.	151·5 oz.	164 oz.
Weight at end of second fortnight . . .	146·5 oz.	162·75 oz.	196·5 oz.
Weight at end of third fortnight . . .	153 oz.	170·5 oz.	221 oz.
Weight at end of fourth fortnight . . .	165·25 oz.	172·25 oz.	241 oz.
Weight at end of fifth fortnight . . .	189·5 oz.	175 oz.	254·75 oz.
Weight at end of eleventh week	193·25 oz.	180 oz.	265·75 oz.
Percentage of increase from birth . . .	88 per cent. nearly	25 per cent. nearly	84 per cent.

These figures speak for themselves, and show that the nursed child developed about three times as fast as the two which were hand-fed.

Absolutely fresh milk, while it is still warm from the animal, has always had a good repute for its nourishing power, and in history there are instances of aged people being kept alive by wet nurses. This is recorded of Dr. Caius, one of the early Presidents of the Royal College of Physicians and the founder of Caius College, Cambridge.

In November 21, 1667, Pepys writes: "With Creed to a Tavern. On this occasion, Dr. Whistler (President of the Royal College of Physicians) told a pretty story, related by Muffet, a good author, of Dr. Caius that built Caius College; that being very old, and living only at that time upon woman's milk, he, while he fed upon the milk of an angry fretful woman, was so himself; and then being advised to take it of a good-natured, patient woman, he did become so beyond the common temper of his age."

Most of the proved and acknowledged dangers of milk, which are dangers inseparable from its manipulation, are abolished by bringing the consumer into direct contact with the producing animal and drinking it 'hot from the cow.'

There is still, I believe, a solitary cow in St. James's Park, to remind Londoners that their ancestors were believers in naturally warm milk; and if dairymen persist in the dangerous practice of adding preservatives and chemicals to the food of our infants, we may live to see the re-establishment of the old custom, or something like it.

It is greatly to be desired that our herds should be composed of healthy animals—in that we are all agreed—but to advise that, because of the dangers of milk, all our infants are to be fed on sterilised milk or boiled milk, instead of new milk, is to advise a rash experiment, all the more dangerous, as it seems to me, because the effects of such a practice will be difficult or impossible to estimate. It would be a leap in the dark—an arrogant rebuff to Nature, who in such matters is, I believe, a tolerably safe guide.

And here I would take leave to remark that the interests of consumer and producer are not identical in this matter. If the dairyman be allowed to sterilise all his milk, and still to call it 'new milk,' he will be relieved of the danger of losses from his produce 'going bad.' But he will sell us old milk for the price of new milk. There is room here for liberty, and if sterilised milk be labelled and sold as such, its market value would soon be established.

So again the addition of antiseptics to milk or dairy produce ought to be stated on the label. Why should not milk and dairy produce to which chemicals are

added be allowed to find their market value? Personally I regard them as worse than worthless, but I am aware that others hold a very different opinion. A fair market will settle that question. That antiseptics facilitate the trade of the vendor and increase his profits there is no doubt.

Let us have fair labels, and let us adhere to the motto '*Caveat emptor.*'

Having made out what seems to me a fairly strong case in favour of new milk as against manipulated milk, let us turn our attention to the question of meat. In recent years we have had revealed to us the remarkable effects produced in certain individuals by feeding on the raw fresh thyroid gland of a sheep. The cretinous dwarf has been seen to grow four or five inches in a year, and to undergo an intellectual development on a par with the physical change. The sufferer from obesity sheds his fat while his pulse is quickened and the output of urea is increased. The sufferer from myxoedema regains her normal briskness and much of her natural comeliness, while hair may, in some cases, be seen to replace baldness, and the skin of the sufferer from psoriasis become again as the skin of a little child.

We have learnt that this potent medicine must be used with great caution, and we have further learnt that the thyroid gland, in order to produce its full effect, must be *fresh* and must *not* be *cooked*. The chemist can tell us very little as to the difference between cooked thyroid and raw thyroid, between fresh thyroid and old thyroid, and yet dietetically there is an enormous difference.

A fact of this kind seems to go far towards justifying the popular prejudice in favour of 'underdone' meat, and the very general impression among doctors as to

the value of raw meat in certain conditions of impaired nutrition. These dietetic problems are not susceptible of rigid proof, but most of us are agreed that the raw living oyster is a very digestible and stimulating food, and that a new-laid egg beaten up with new milk and taken raw is a food of great and acknowledged value. We are not much given in this country to the consumption of uncooked meat, but I would remind you that in many parts of the world meat which has been slightly salted and dried has a great reputation for its nutritive and stimulating qualities. Beef may be bought in London, under the name of hung beef or Hamburg beef, which has been thus treated, and which is enjoyed by many, and is easily digested. In Germany hams and some forms of sausage are eaten without being cooked, and the stimulating quality of the food is said to outweigh the slight extra risk of trichinosis. Among the advantages which the Boers have had over us in South Africa must be reckoned the very portable sun-dried food called 'biltong.'¹

¹ In the *British Medical Journal* for April 12, 1902, Professor Halliburton, F.R.S., gives the following analysis of biltong made from a sample at least two years old.

Composition of Biltong

Water	19·410 per cent.
Solids	80·590 "
Inorganic solids	6·592 "
Organic solids	73·998 "
Proteids	65·866 "
Fat (ether extract)	5·140 "
Glycoegen	0·188 "
Sugar	0·090 "
Extractives (by difference)	2·769 "

Professor Halliburton testifies to the ready digestibility of biltong, and says that his experiments, both from the chemical and physiological standpoints, testify to its valuable nutritive properties.

This, I believe, should, correctly speaking, be made of the loin muscles of a deer. Biltong made from the ox appears to be equally valuable. With a piece of biltong attached to the saddle, and a knife to cut it, the commissariat department is at once simple and effective. I have met English officers who were loud in praise of biltong as a war ration.

In hot dry countries sun-dried uncooked meat is much used by those who spend long hours in the saddle.

In a moist climate like England the preservation of dried meats is not to be done without great care.

It may be well to direct attention to the fact that certain beasts which feed but seldom, such as snakes, will not eat dead food, but only consume animals which they kill themselves. It is interesting also to observe how domestic carnivora, such as cats and dogs, when burdened with the cares of a family, will often prowl about in search of living prey. When I see my cat incessantly stalking sparrows and making excursions for mice to an inordinate extent, I know that she has a litter of kittens, and I have also observed the same propensity in a brooding bitch.

These facts have induced me to carry out some experiments, or rather to ask my friend and former pupil, Dr. Thiele, to carry out some experiments for me, on the relative digestibility of meat under the three conditions in which we know it, viz.:—(a) Immediately after death, before rigor sets in; (b) during rigor; and (c) after rigor, when the meat has become tender again.

The result of these experiments so far has been to show that in the usual mixture of HCl and pepsin in one and a half hours the ante-rigor meat proves

25 per cent. more digestible than meat which has entered into rigor. The post-rigor meat is not more digestible than the meat in rigor. The ease with which the muscle fibre undergoes peptisation before rigor seems to furnish a justification for the conduct of carnivora which hunt their prey. Man very seldom consumes meat before the advent of rigor, never, probably, except when eating oysters. An officer just returned from Africa, who takes a most intelligent interest in these important dietetic questions, told me that he was present on an occasion when some deer got surrounded by a regiment of our men, and were shot down, skinned, and eaten then and there before the onset of rigor. He said they were very good eating, and were much enjoyed as a change from tough draught-ox and 'bully beef.'¹

¹ In *My Mission to Abyssinia*, by Gerald Portal, I find the following footnote (p. 188): "Mansfield Parkyns (*Life in Abyssinia*, ch. xxvii. vol. i.) gives the following description of 'brundo' eating. The slaughtering of animals in Abyssinia is attended with a regular ceremony, as in Mohammedan countries. The animal is thrown down with its head to the east, and the knife passed across its throat, while the words 'In the name of the Father, Son, and Holy Ghost' are pronounced by the butcher. Almost before the death struggles are over persons are ready to flay the carcass, and pieces of the raw meat are cut off and served up before this operation is completed; in fact, as each part presents itself it is cut off and eaten while yet warm and quivering. In this state it is considered, and justly so, to be very superior in taste to what it is when cold. Raw meat, if kept a little time, gets tough; whereas if eaten fresh and warm it is far tenderer than the most tender joint that has been hung a week in England. The taste is, perhaps from imagination, rather disagreeable at first, but far otherwise when one gets accustomed to it." Portal says, "But although we saw nothing of it, Bruce Mansfield Parkyns, Mr. Dufton, and Mr. Rassam all speak of the fondness of the Abyssinians for what they call *brundo*, i.e. a piece of raw meat cut from the carcass at the very moment when the animal is killed, and eaten probably with the inevitable red-pepper sauce before it has had time to grow cold."

The flesh of the coursed hare is said to be much appreciated by epicures, and the reason given is that rigor has passed off before the animal is eaten. On the other hand, I am told that hunted stag is 'horrid to eat,' because 'the fat gets all mixed up with the meat in some way.' The contrast between the hunted hare and the hunted stag is, if corroborated, interesting, and seems worthy of attention. I have no personal experience in the matter. The hare is an animal which carries no fat.

The chemist can tell us very little as to the difference between muscles in a condition of ante-rigor, rigor, and post-rigor, and yet we find that their solubility in digestive fluids differs considerably. We practically never eat meat except in a condition of rigor or post-rigor, when it is relatively indigestible. When a joint of fresh meat is 'hung' in a pure place, it ripens and gets tender and delicious before putridity sets in. We have no certain knowledge as to the cause of this 'ripening,' and one naturally asks, 'Is it microbial? Has the joint of meat served as a cultivating medium for a vegetable growth of which the products are pleasing to the palate?' The ripening of meat does not, if one may judge by the palate, take place in the ice-chest, nor is it possible when it comes out. Some of us are, I think, too ready to judge of the nutritive qualities of food by looking at the chemical analysis. We forget that it is not that which we put into our mouths which nourishes us, but that which we digest and absorb.

Digestion depends upon the condition of the digestive organs, and these are stimulated to activity by the sensory nerves of the mouth, tongue, palate, nose, and eye. Our appreciations of different kinds of food vary with the individual. In this, as in all other matters,

no two of us are alike. As digestion depends upon the degree to which the flow of secretion from the alimentary tract is stimulated by our sensory nerves, we may fairly conclude that the food which is eaten with appetite and liking is more useful than that which we swallow as a duty, but with loathing, loathing so great that sometimes the stomach instantly rejects its contents. We cannot, happily, get away from that inscrutable craving called appetite—a craving which surely guides the sane man to a selection of food which is suitable for him, and further prompts him to that change of diet which appears to be essential for our well-being.

Lind ('A Treatise on the Scurvy,' page 78) says : "Our appetites, if they are not depraved, are upon this and many other occasions the most faithful monitors, and point out the quality of such food as is suited to our digestive organs, and to the state and condition of the body. For where there is a disposition to the scurvy from a long continuance in the moist sea-air, concurring with a glutinous and too solid diet, Nature points out the remedy. In such a situation the ignorant sailor and the learned physician will equally long with the most craving anxiety for green vegetables and the fresh fruits of the earth, from which only relief can be had. Such people, in the height of the disease, not only employ their thoughts all day long in satisfying this importunate demand of Nature, but are apt to have their deluded fancies tantalised in sleep with the agreeable ideas of feasting upon them at (*sic*) land."

Lind, in addition to lemons, fresh vegetables, oranges, pickles, sauerkraut, &c., advocates the use of fresh *fermented* bread and *fermented* drinks, such as cider, beer, spruce beer, and wine (such as Malaga

and home-made wines). Spirits he considers bad for the scurvy, and when used they must have some lemon juice or a slice of lemon added. One of the best remedies is to give lemon with Malaga. Sugar and molasses, added to wine to start fermentation afresh, are advocated.

With the growth of our cities, it becomes increasingly difficult to supply their populations with really fresh food. In London we seldom eat fish in really fine condition. The refrigerator enables us to get it free from putrefactive changes, but few Londoners have ever eaten fish in that crisp, curdy condition which it is in when fresh caught. In the present year I have twice visited Newcastle, and have been much struck by the excellence of the fish, due, as I was informed, to the fact that the fishing smacks unload in what is almost the centre of the town. The fish are not only fresh, but new-caught. There is the same kind of difference between fish which have been for days in a refrigerator and new-caught fish that there is between new-laid eggs and 'shop' eggs.

The difference between fresh vegetables and those which have been a day or so on a greengrocer's stall is admitted by most of us. Few persons, however, who have not a garden of their own know the flavour of really new-gathered vegetables. Asparagus, peas, beans, and even cabbages which are taken direct from the garden to the pot have a flavour which can and ought to be appreciated.

While on the subject of new-gathered food, allusion may be made to the great and deserved popularity of those vegetables which we habitually eat raw, such as ripe fruits, lettuce, endive and other salads, watercress, celery, and, among the poor especially, onions and garlic.

How much some of these vegetables lose by cooking

is best seen in the onion, which after cooking is but a shadow of its former self. We must include butter and cheese among the foods which are habitually taken raw, and of whose highly nutritive qualities one can have no doubt. It is obvious that modern cheap substitutes for butter and cheese belong to an entirely different class.

X I have thus far offered you a good deal of evidence that many foods are more valuable raw than cooked, and more valuable new than old. The nutritive value of a food is proportioned to its digestibility and its power to stimulate appetite and digestive secretions. Apart from such considerations mere chemical analysis is worthless, and I must confess that personally I am in no way converted to the belief that meat which has been refrigerated is at all the equal of new meat which has been hung. Refrigerator meat is often sold without warning; and I am rather repelled by joints which are deficient in fat; in which the cellular tissue shrinks upon the bones, like the jacket of a growing schoolboy on his arms; in which the first cut sometimes lets out a spirit of watery fluid; in which the fibres gape, and the meat is tasteless, stringy, and flabby, and very often not done in the centre. Such a joint is to a really fresh joint what a 'shop egg' is to one which is new-laid.

I am quite ready to admit that refrigerated meat is better than putrid meat; I am aware that there are those who state that it is *better* than fresh meat. Nevertheless, I am of opinion that every carcass of meat should bear upon it the date of slaughtering.

A week or two since I walked through a village street near London on a Saturday night.

The grocers' shops were piled from floor to ceiling

with tinned provisions ; most of the butchers' shops were hung with joints shiny with moisture or absolutely dripping, showing that they were fresh from the refrigerator ; and the vendors of fried fish were busy in putting flabby blue sodden-looking stuff into boiling oil, and making a fume which drifted for a quarter of a mile down wind. It is needless to say that a refrigerator is a famous invention for vendors, who are thereby enabled to keep food for a good market, and are never compelled to sell hurriedly at 'an alarming sacrifice.'

The question whether this old food has the same value as fresh food is one which it is difficult to answer, but in the present state of our ignorance there ought to be no risk of our mistaking the one for the other. In the same way 'tasteless antiseptics,' such as boric acid, ought not to be added to food unless the fact be clearly stated. It is surely as dangerous to keep a baby too exclusively on pickled milk as it is to keep a sailor too exclusively on pickled pork.

We are as yet quite ignorant of the *vera causa* of the scurvy, which seems to make its appearance when persons are deprived of *fresh* food. No chemical theory as yet put forward has afforded an adequate explanation. With fresh vegetables, and to a less extent with fresh recently killed meat, scurvy may be warded off, but apparently it is not to be warded off by tinned provisions, nor even by lime-juice which has been kept too long.¹

¹ In the account of the siege of Lucknow, in *Recollections of my Life*, Sir Joseph Fayrer mentions the intolerable stench from the unburied carcasses of horses, and the insufferable nuisance of flies, and on page 191 he says : 'One of our greatest wants is that of vegetable food, and the men risk their lives daily to gather the leaves of a wild cruciferous plant growing amongst the ruins ; this is much prized as a green vegetable. Scurvy is prevailing, and the want of this article of diet is severely felt.'

Lind's advocacy of fermented foods, such as beer and bread, is interesting, and that leads me to say that to speak of beer as an 'alcoholic' food, and to gauge its value or the reverse by its percentage of contained alcohol, is a mistake. Beer is the fresh product of a cultivation of a species of *saccharomyces* in an infusion of malt, just as bread is the production of an allied fungus growing in dough. Alcohol and starch, *per se*, have no antiscorbutic power, but beer and bread, which result from fresh vegetable growths, are both of them credited with the power of keeping off scurvy.

In the same way butter and cheese are both of them the products of microbic growth upon certain milk products. Cheese is at its best when it is thoroughly 'ripe,' but it must be regarded as fresh food to the end, because it is the ever-growing microbe and its products which really constitute the attractive features of cheese.

We have given conventional names to certain products without reference to chemistry.

Butter is a dairy product which takes some days to make. Attempts have been made to hurry the process by rapidly separating the cream by means of machinery. 'Separated' cream will furnish a very edible grease of uniform quality, but it has never fallen to my lot to eat a really fine sample of butter (judged by flavour) which has been made with 'separated' cream.

Nature refuses to be hurried, and it remains to be seen whether the various 'ripeners' (*i.e.* pure cultivations of microbes) will bestow the true flavour upon 'separated' butter. Margarine has no resemblance on the palate to fresh butter, and is not in any sense a fresh food. To my thinking it is inferior in flavour to good dripping.

What is true of butter is true of cheese, and imitations of cheese hurriedly made with the aid of fat and chemicals ought to be marked.

The ripening of food such as hams, bacon, wine, and even spirits is probably a biological process.

Attempts have been made to make 'temperance' drinks without having recourse to fermentation, by artificially 'charging' mixtures of syrup and flavourings with carbonic acid. It is very interesting to see how singularly the attempt has failed, and how in the summer the demand is everywhere for 'stone-bottle ginger beer' (*i.e.* fermented) in preference to the imitation article. I lately tasted an imitation ginger beer which was a thin liquor, perfectly brilliant, very sweet, and which made one sneeze. At a guess I thought it was a mixture of water, saccharin, and formic aldehyde charged with carbonic acid.

It is singular, but I think true, that liquids which effervesce as the result of fermentation, and those which are 'charged' with carbonic acid, taste quite differently, and, moreover, the effervescence of fermentation is far more persistent. The practice of 'charging' the cheap effervescent wines and bottled beers is one which ought to be watched. In the same way aerated bread and fermented bread cannot be mistaken for each other. From my point of view the former is not 'bread' in the true conventional sense. Baking powders produce an aeration of farinaceous food very different from fermentation, and not acceptable to all of us.

The chemist is showing very great ingenuity in imitating Nature, and in furnishing 'synthetic products,' which are often made from manufacturers' 'waste.' We have a right to demand that these imitation foods

should be clearly labelled. We should then soon arrive at their true market value; and we must not allow old food, whether refrigerated or pickled, to be sold for new food, and the mixing of chemical products with natural products should be absolutely forbidden unless it be fairly stated on the label.

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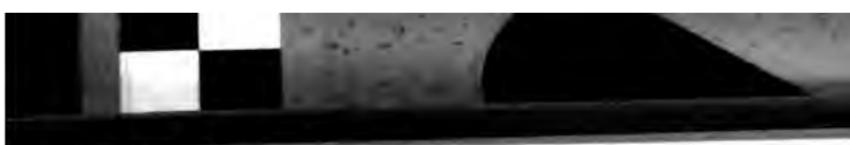
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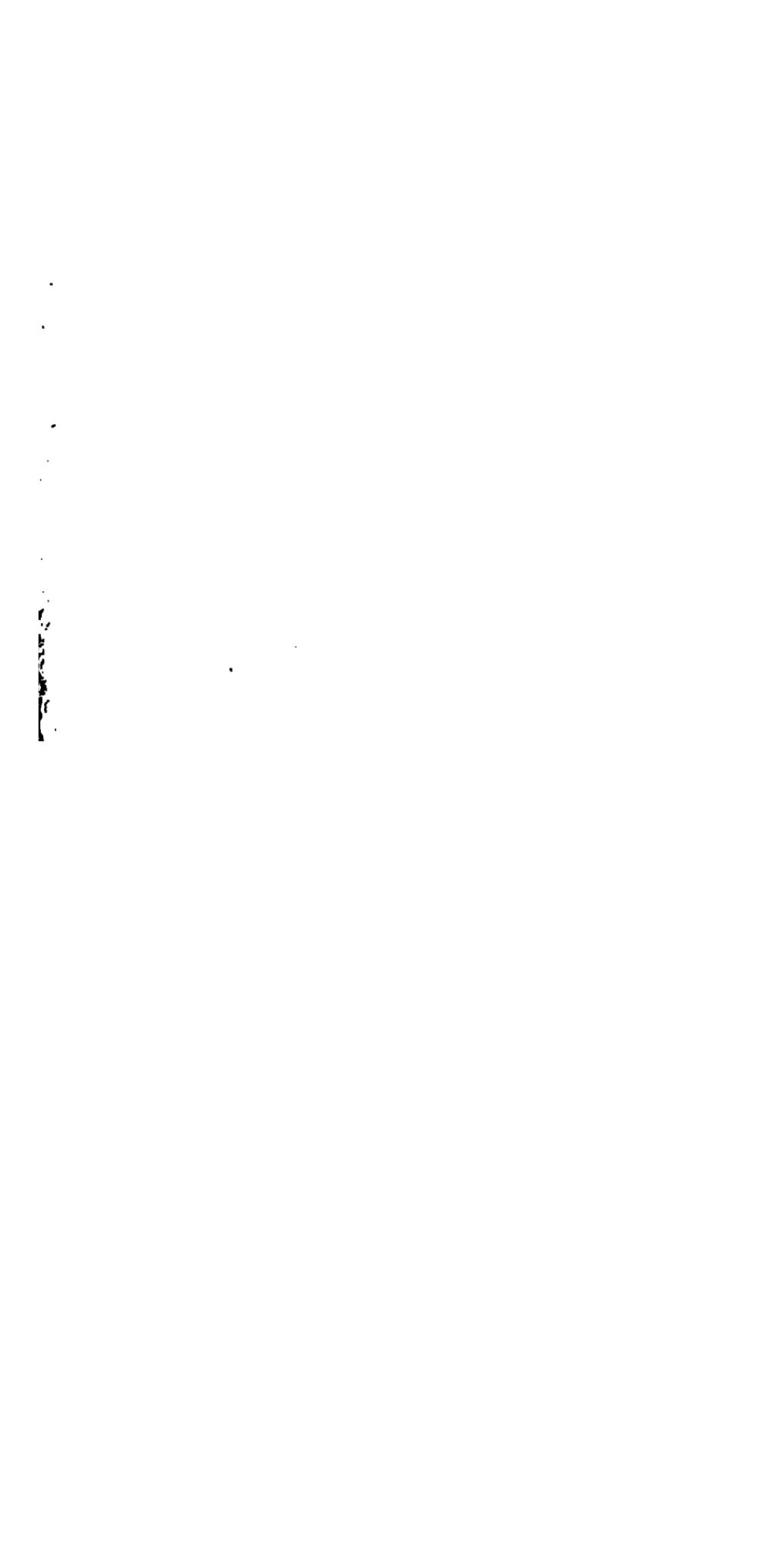
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